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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering and Standardization of Specifications and Methods of Testing"

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Number 116 May, 1942

Forty-fifth Annual Meeting

Provisional Program Shows Eighteen Technical Sessions, 100 Reports and Papers; 150 Committee Meetings Contemplated

From the Provisional Program published in this Bulletin it will be seen that a number of very interesting technical sessions have been planned for the Forty-fifth Annual Meeting of the Society to be held at Chalfonte-Haddon Hall, Atlantic City, Monday, June 22, through Friday, June 26. The program, published later in this issue, is particularly significant, since it not only will enable members to determine preferences for sessions they wish to attend, but it also gives synopses of the papers and reports and enables members to check the Preprint Request Blank which is being sent under separate cover simultaneously with the mailing of this Bulletin.

Eastern Coast Dim-out

The officials of the Society have been following very closely the developments in recent months on the Eastern Seaboard which may affect the holding of a meeting in Atlantic City. A dim-out of lights has been ordered by the War Department but unless more drastic measures are ordered, it would be entirely practicable to hold the meeting under existing conditions. The hotel is making provisions so that there will be a minimum of inconvenience to guests in connection with the dim-out. The technical program is being arranged so as to concentrate committee meetings during the day and the program is arranged in other respects having in mind the present conditions.

If eventualities should arise—and such are certainly not anticipated—which would make a sudden shift of the meeting necessary to some inland center, arrangements have already been discussed with hotels in other localities so as to effect a shift quite promptly. Members and committee members would receive immediate notification of the change in plans.

Change in Opening Session

Perhaps the most notable change in the program this year is the decision to combine some of the features of the formal opening session held in previous years with events during the middle of the week (Wednesday) when attendance at the meeting is usually at a peak.

From the Provisional Program it will be noted that the President's Address is scheduled for Wednesday evening at which time it is planned also to have some prominent national figure address the meeting.*

Technical Program

Frequently, because of the unusual timeliness of a topic, or because of great activity by a technical group in arranging a symposium or technical discussion to be held at the A.S.T.M. annual meeting some subject may be very prominent in the week's program, and that is the exact situation this year. The Symposium on Radiography being held in three sessions—Tuesday morning, afternoon and evening—is not only most timely because of the very wide use of this nondestructive method of testing in connection with so many materials vital in the emergency, but Committee E-7 on Radiographic Testing which has had a group headed by Lars Thomassen developing this symposium, has received splendid cooperation from a number of leading authorities in the field as listed in the Provisional Program.

Other noteworthy features of the meeting include the session on water, Tuesday afternoon, featured by the Round-Table Discussion on Solvent Action of Water Vapor at High Temperature and Pressure, which has been arranged through the activities of Committee D-19 on Water for Industrial Uses. Though scheduled as a round-table discussion, R. E. Hall, Director, Hall Laboratories, Inc., *Secretary*, and Max Hecht, Adviser, Power Stations Chemistry, *Chairman*, have been very successful in obtaining formal discussion from a number of outstanding experts on various phases of the problem.

Another session which is particularly timely will comprise a Round-Table Discussion on Alternate Alloy Steels and Conservation of Strategic Alloys. A number of outstanding metallurgists and those concerned with this field will participate. The session was suggested because of the very vital interest in the so-called "8000 series" of alternate steels which are for the most part manganese-molybdenum or nickel-chromium-molybdenum compositions in

low percentages which are suggested as alternates for higher alloy compositions. The session will afford an opportunity for correlating latest information on many of these steels, heats of which are being poured and tests are under way. John Mitchell, Metallurgical Engineer, Alloy, Carnegie-Illinois Steel Corp., chairman of the National Emergency Steel Specifications Technical Advisory Committee on Carbon- and Alloy-Steel Bars, Blooms, Billets and Slabs, is cooperating closely in the development of this session and will serve as chairman of the session.

It will be noted that the third session of the meeting is devoted to electrical insulating materials, paint, rubber, and textiles. The sixth session featuring chiefly plastics and timber will include a number of interesting papers. Recent A.S.T.M. meetings have featured very valuable contributions in the plastics field and this should be no exception. The eight and ninth sessions, it will be noted from the Provisional Program, deal with road and paving and bituminous materials and the ninth covers fuels and lubricants. A number of important committee reports feature the tenth session on steel, and effect of temperature.

The thirteenth session on methods of testing and fatigue is a rather heavy one, with several notable technical papers scheduled including discussion of the scanning electron microscope, discussion of methods of testing hydrometers, and papers dealing with fatigue and methods of evaluating damage caused by fatigue. The fourteenth session on non-ferrous metals includes, like similar sessions in previous years, a number of important committee reports.

The present emergency has focused special attention on quite a number of materials, including cast iron which will be the chief subject matter of one of the two sessions being held on Thursday evening. The other covers cementitious materials with papers dealing with mortars, mortar properties, and committee reports. Of the two Friday sessions, one covers brick, refractories, insulating materials, and the last one on Friday afternoon features a number of technical discussions on concrete and concrete aggregates and will also include the Sanford E. Thompson Award.

The various sessions have been developed and scheduled keeping in mind the chief interest of groups of A.S.T.M. members, many of whom have been consulted. While it is not anticipated that any major shifts in the makeup of the program will need to be made this year, although some minor additions, or changes in time, may be necessary as they frequently are even in normal times, an effort will be made to communicate with members advising of any major changes which may develop due to unforeseen circumstances.

Edgar Marburg Lecture—Medal Awards

On Wednesday, June 24, very probably at 4 p.m., although some shift in this may be announced later, the Seventeenth Edgar Marburg Lecture on the subject, "Gasoline—Past, Present, and Future," will be delivered by Dr. Graham Edgar, Director of Research, Ethyl Gasoline Corp. Some notes on Doctor Edgar and the Lecture are given on a succeeding page of this Bulletin.

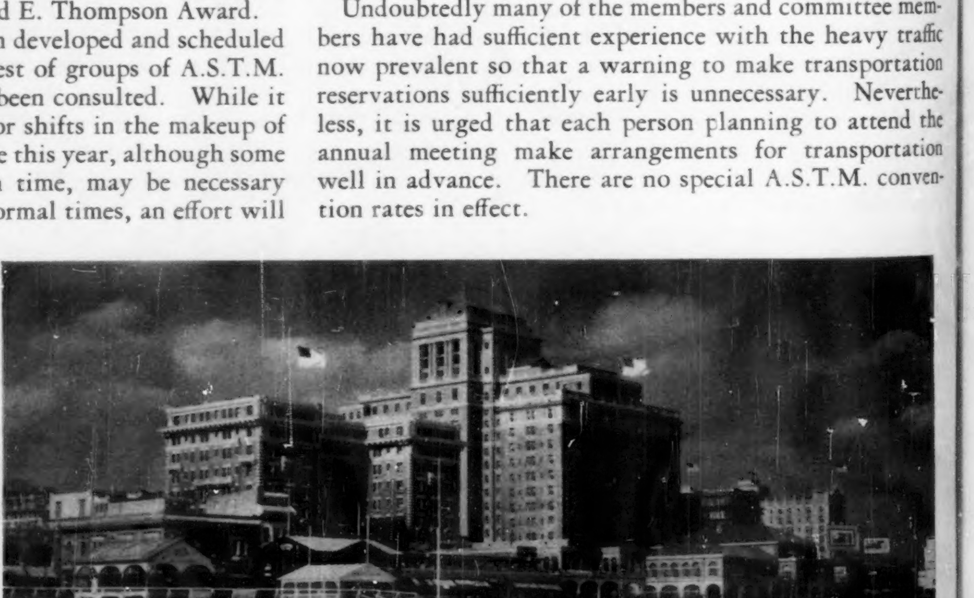
At this time there will also be presented to F. C. Todd, Assistant Professor, Petroleum and Natural Gas Engineering, The Pennsylvania State College, and A. W. Gauger, Director, Mineral Industries Research, The Pennsylvania State College, the 1942 Charles B. Dudley Medal, awarded in recognition of their outstanding paper on "Studies on the Measurement of Water Vapor in Gases" presented at the 1941 annual meeting in Chicago. The Third Sanford E. Thompson Award, which is presented by A.S.T.M. Committee C-9 on Concrete and Concrete Aggregates to the author of the outstanding paper dealing with concrete and concrete aggregates, will be presented in the concrete session, which is scheduled for Friday afternoon at 2 o'clock.

Preprints Sent on Request

In a separate mailing there is being sent to each A.S.T.M. member a Preprint Request Blank by which he can request a copy of any of the technical papers and reports preprinted in advance of the meeting. This blank should be returned promptly and should be carefully marked. The Provisional Program will enable members to make a selection of the items desired. Preprints will be forwarded to those members in good standing, probably in three installments. *Members should note that preprints will not be sent unless requested.*

Transportation Reservations Should Be Made Early

Undoubtedly many of the members and committee members have had sufficient experience with the heavy traffic now prevalent so that a warning to make transportation reservations sufficiently early is unnecessary. Nevertheless, it is urged that each person planning to attend the annual meeting make arrangements for transportation well in advance. There are no special A.S.T.M. convention rates in effect.



Hotel Reservations, Advance Registration

It is desirable that all members should make their hotel reservations promptly and for this purpose a return blank addressed to the hotel management, Chalfonte-Haddon Hall, is being sent in a separate mailing. Rooms can be secured on either the American or European plan at the special rates listed on the return blank. Since Chalfonte and Haddon Hall each has its own dining room service, members who wish to dine together should secure accommodations in the same division of the hotel, particularly if they are registered on the American plan.

In order to expedite registration of members at the meetings, it is desirable to have as many registration details as possible taken care of in advance and it would be very helpful if members would fill out and mail promptly to A.S.T.M. Headquarters the advance registration card that is being sent.

Entertainment

Although there will be no ladies entertainment committee organized this year, the ladies and others of members' families are urged to register at the A.S.T.M. registration desk. Each lady will be furnished with tickets for roller chair rides and admission to the Steel Pier. There will be a ladies' headquarters and bulletin board and entertainment features which may be developed at the meeting will be publicized.

Golf Tournament.—Because of the present emergency situation, the customary annual golf tournament is not being held, although members who do wish to enjoy some relaxation on the links should not hesitate to bring their clubs with them because facilities will be made available, probably at the Seaview Country Club. Information will be available at the A.S.T.M. Registration Desk.

Graham Edgar—Marburg Lecturer

Gasoline—Past, Present, and Future

Dr. Graham Edgar, Vice-President and Director of Research, Ethyl Gasoline Corp., New York City, has accepted the Society's invitation to deliver the Seventeenth Edgar Marburg Lecture at the Forty-fifth Annual Meeting, Atlantic City, on Wednesday, June 24.

A foremost authority in this field, Dr. Edgar plans to cover some of the problems which are vital in connection with the present emergency. A brief statement of the scope of the lecture has been received as follows:

Starting with the A.S.T.M. definition of gasoline as "suitable for an internal combustion engine," this lecture discusses the close relationship between the characteristics of gasoline and the characteristics of the internal-combustion engine. The significance of the A.S.T.M. tests for gasoline is discussed together with trends of the physical and chemical nature of gasoline over a period of years, the impact of the war on gasoline, and the probable future trends in gasoline after the war.

A native of Arkansas, Dr. Edgar received his college training at the University of Kentucky where he received his B.S. degree in 1907. He then studied at Yale where the Ph.D. degree was awarded him in 1909. For the next eight years, through 1917, he was Assistant and later Associate Professor of Chemistry at the University of Virginia. He was then for a year Professor of Chemistry at the California Institute of Technology. Upon the completion of this year, he returned to the University of Virginia where for five years he was Professor of Chemistry.

In 1924 he was appointed Director of Research of the Ethyl Gasoline Corp. and was elected Vice-President in 1932.

He has been very active in the work of many technical and professional organizations, serving in various capacities in these groups. His present memberships include American Chemical Society, American Petroleum Institute, Society of Automotive Engineers, Institute of Aeronautical Sciences, and the American Society for Testing Materials. In A.S.T.M., in which he has held membership for the past twelve years, he is particularly concerned with the activities of Committee D-2 on Petroleum Products and Lubricants. He has been a member for many years of its Technical Committee A on Gasoline and serves as Chairman of Section VII on Tetraethyl Lead in Gasoline.

In no other field of engineering materials has the influence of A.S.T.M. standardization and research been more pronounced than in petroleum products where the some 60 widely used specifications and test methods developed through the work of Committee D-2 are in widespread usage and the research sponsored by the committee resulting in technical papers and reports over many years have greatly increased our knowledge of the production, use, and evaluation of the many products.

Addenda to List of Emergency Alternate Federal Specifications

As previously announced, the Specifications Branch, WPB Bureau of Industrial Conservation, issued as of January 26 a list of Emergency Alternate Federal Specifications. This has now been supplemented by an additional list of the Federal emergency items as of March 31, 1942. Copies of the original and the Addenda list can be obtained from A.S.T.M. Headquarters as long as the supply lasts. There is no charge.

Detroit District Is Affiliate Member of Detroit Engineering Society

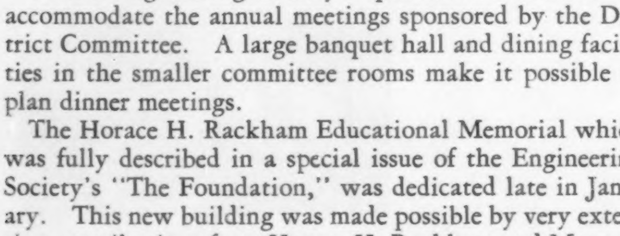
IN THE FALL OF 1941 the Detroit District Committee, with the approval of the Executive Committee of the Society, applied for and was granted an affiliate membership in the Engineering Society of Detroit. As an affiliate member, the Detroit District Committee, A.S.T.M., representing the national organization in the Detroit metropolitan area, becomes one of seventeen such members, enjoying privileges of the Engineering Society's new quarters in the recently completed Horace H. Rackham Educational Memorial Building. Through this association with the Engineering Society of Detroit, A.S.T.M. now has an official Detroit address through which queries concerning membership and publications may be routed to the proper local officers.

Representatives of the Detroit District Committee sit on the Affiliate Council of the Engineering Society and thus make it possible for A.S.T.M. to take an active part in local cooperative educational or promotional engineering projects.

It is felt that this association will have definite promotional advantages for A.S.T.M. and through it that local A.S.T.M. members will have a greater opportunity to cooperate in the educational efforts of engineers in the Detroit area.

In the Engineering Society's quarters are facilities to accommodate the annual meetings sponsored by the District Committee. A large banquet hall and dining facilities in the smaller committee rooms make it possible to plan dinner meetings.

The Horace H. Rackham Educational Memorial which was fully described in a special issue of the Engineering Society's "The Foundation," was dedicated late in January. This new building was made possible by very extensive contributions from Horace H. Rackham and Mary A. Rackham. The complete building is actually two units and houses the Detroit Engineering Society and Detroit office of the University of Michigan Extension Service. The building is located in Detroit's Art Center which also includes the Detroit Institute of Art and the Detroit Public Library. Some idea of the size of the structure is indicated by its length—404 ft.—with a depth of 65 ft. at the ends and 150 ft. in the center section, this latter housing the Main Auditorium. The east wing is occupied by the Engineering Society, and the west wing, the University activities. The accompanying architects' scale drawing should give a conception of the nature of the building. Martin Castricum and C. H. Fellows represent the A.S.T.M. on the Affiliate Council of the Society.



No Preference Ratings Necessary in Shipping "8000 Series" Steel Specimens for Test

STEEL COMPANIES melting so-called National Emergency Alloy Steels have been given authority to ship specimens to laboratories or manufacturers without regard to preference ratings, the WPB announced April 14. The purpose is to obtain the widest possible testing of these new steel alloys, which reduce quantities of alloys used and are based upon the principle that small quantities of certain alloying elements may be more effective than larger quantities of a single element.

Those receiving these steels must certify in their purchase orders that the material will be used for experimental purpose; that the amount ordered, together with any on hand or on order from other mills, will not exceed 500 lb. for any one specification, and that the total on hand or ordered for all types does not exceed ten tons.

The authority extends until July 31.

There was a complete list of these "8000 series" steels and how they would serve as possible alternates for standard series A.I.S.I. and S.A.E. numbers, published in the March, ASTM BULLETIN, p. 46, which also stressed the necessity of developing needed information as quickly as possible. Any data developed should be forwarded promptly to L. E. Ekholm, Metallurgical Engineer, Alan Wood Steel Co., who is chairman of the special committee on research functioning under the NESS Technical Advisory Committee on Carbon and Alloy Steel Bars (TAC 7).

Nominations for Officers

THE NOMINATING COMMITTEE to select nominees for Society officers met in Philadelphia on March 6. The personnel of this group was listed in the March BULLETIN. In accordance with the provisions of the By-laws of the Society, the following nominations are announced:

For President:

H. J. Ball, Professor of Textile Engineering, Lowell Textile Institute, Lowell, Mass.

For Vice-President:

P. H. Bates, Chief, Clay and Silicate Products Division, National Bureau of Standards, Washington, D. C.

For Members of Executive Committee:

R. P. Anderson, Secretary, Division of Refining, American Petroleum Institute, New York, N. Y.

M. H. Bigelow, Director of Technical Service, Plaskon Co., Inc., Toledo, Ohio

J. H. Foote, Supervising Engineer, The Commonwealth & Southern Corp., Jackson, Mich.

L. H. Fry, Railway Engineer, Edgewater Steel Co., Pittsburgh, Pa.

Alexander Foster, Jr., Vice-President, Warner Co., Philadelphia, Pa.

Each of the above nominees has indicated in writing his acceptance of his nomination. The By-laws provide that "further nominations, signed by at least 25 members, may be submitted to the Secretary-Treasurer in writing by May 25, and a nomination so made, if accepted by the member nominated, shall be placed on the official ballot" which "shall be issued to the members between May 25 and June 1."

Accelerated Testing of Paint Coatings

Results of Questionnaire

Prepared by H. G. Arlt[1]

A Symposium on the Correlation Between Accelerated Laboratory Tests and Service Tests on Protective and Decorative Coatings[2] was held at the 1937 Annual Meeting of the American Society for Testing Materials. It was intended that this symposium would, first, disclose either unknown or common types of accelerated laboratory tests, and, second, describe the extent and reliability of their use. It was clearly brought out that there were three general methods of accelerated testing employed to determine the durability of paint coatings:

1. The use of an accelerated weathering machine or cycle to reproduce in a single test all of the factors encountered under service conditions and to produce failure in the organic finish resembling that found in service;
2. The use of a method of test to produce any one particular type of failure such as checking, chalking, fading, etc., or to measure the extent of this particular type of failure; and
3. The use of an accelerated or normal aging test of relatively short duration and the application of a combination of sensitive test methods which would disclose the rate of change of the basic physical properties of the organic coating at an early stage in its life, from which data the expected life and type of failure might be predicted.

Although many conflicting opinions existed, it appeared, in general, that many useful accelerated tests had been developed, but that no single machine or apparatus was available which perfectly reproduced the characteristic failures encountered in service. It was further recognized that while accelerated weathering machines did not simulate the weathering encountered by organic coatings in use, possibilities existed in the development of these machines in that certain cycles appeared consistently to reproduce particular types of failure.

There has been much discussion both at the symposium and since that time as to the relative merits of the first test method using appearance changes, produced by an accelerated weathering machine or long-time outdoor exposure tests, as a criterion of the durability of organic coatings *versus* the third test method using the rate of change of physical characteristics, produced by accelerated or normal aging tests, as a measure of the durability of paint coatings.

The first method often necessitates a rather complete breakdown of the film before an evaluation can be made as to its durability. It means that a long exposure or service test must be made or that an accelerated weathering cycle must be used that duplicates the weathering conditions expected in service. The discussion indicates that a reproduction of service weathering has not yet been attained. This may be due to the fact that weathering encountered in service is variable while most of the accelerated weathering cycles in use at the present time subject the test specimens to a repetition of a fixed set of conditions.

The third method allows interpretation of the physical state of the organic finish long before appearance changes are noticeable. An interpretation of the physical state of the film can be followed by a prediction of its durability.

Objectives

Since the 1937 Symposium there has been a strong feeling that the whole subject of accelerated testing of paint coatings should be clarified by collecting the opinions of producers and users of paint products. It was realized that a well-planned investigation of this sort could be of considerable value in leading toward the development and standardization of A.S.T.M. methods for the accelerated testing of organic coatings.

Committee D-1 on Paint, Varnish, Lacquer, and Related Products, through its Subcommittee VII on Accelerated Tests for Protective Coatings (H. A. Nelson, *Chairman*), appointed the following Group to proceed with this project:

H. G. Arlt, *Chairman*—Bell Telephone Laboratories, Inc.
C. W. Jameson—Atlas Electric Devices, Inc.
W. H. Lutz—Pratt and Lambert, Inc.
C. C. Ollinger—National Carbon Co.
G. G. Sward—National Paint, Varnish and Lacquer Association

This group was entrusted with the responsibility of preparing and circulating a questionnaire, having in view the following objectives:

1. To determine the interest and extent of use of accelerated testing;
2. To determine the frequency of use of accelerated and nonaccelerated tests in the evaluation of the properties that indicate service qualities of organic coatings;
3. To determine whether the producers and users of paint products have confidence in the ability of commercial weathering machines and accelerated weathering cycles to evaluate the capacity of paint coatings to withstand indoor and outdoor weathering;
4. To determine whether the evaluation of the durability of paint coatings by commercial weathering machines and accelerated weathering cycles has sufficient promise to warrant continuing with their development and ultimate standardization; and
5. To determine the order of importance of the several steps involved in making outdoor exposure tests with the ultimate view of standardizing such steps.

Questionnaire

In the preparation of the questionnaire,[3] an attempt was made to encourage the interest of those who were to receive it by wording it in an informal and personal manner. The benefits accruing to all by the accumulation of the desired information were pointed out. Cartoons were used to illustrate the questions in order to attract the reader's attention. The questions were so worded as to require a minimum of effort in filling out the questionnaire. In all questions except one, simple check marks only were necessary to furnish the required information. Finally, as an added inducement, a copy of the results obtained was promised to those who filled in and returned the questionnaire.

A mailing list was carefully selected in order to obtain approximately equal representation from producers,

[1] Member of Technical Staff, Bell Telephone Laboratories, Inc., 463 West Street, New York, N. Y.

[2] Issued as separate pamphlet; for résumé, see *Proceedings*, Am. Soc. Testing Mats., Vol. 37, Part II, p. 467 (1937).

[3] Questionnaire on Accelerated Testing of Paint Coatings, Am. Soc. Testing Mats., *Bulletin* No. 107, December, 1940, p. 47.

consumers, and general interests. A total of 1151 copies of the questionnaire were distributed, as follows, and of this number replies were requested from 1011:

- 242 copies to all members of A.S.T.M. Committee D-1,
- 370 copies to members of the Paint and Varnish Division of the American Chemical Society who are not members of Committee D-1,
- 328 copies to selected members of the A.S.T.M., mostly consumers and general interests,
- 100 copies to chairmen of all A.S.T.M. standing committees (sent for information only, no answers requested),
- 21 copies to Paint and Varnish Production Clubs,
- 40 copies to Technical Committee X on Conditioning and Weathering, of Committee E-1 on Methods of Testing (sent for information only, no answers requested), and
- 50 copies to miscellaneous persons and organizations.

The questionnaire was also printed in the ASTM BULLETIN.[3] A total of 343 replies were received of which 11 resulted from the ASTM BULLETIN publicity; 27 returns were received from state highway commissions; and 16 from railroad companies. Of great interest were the 41 letters and notes received with the returned questionnaires. Many writers had taken great pains to express their opinions on the subject, to offer help to the committee, and to clarify their answers. Abstracts from some of the letters are given in the Appendix.

RECORDING OF DATA

An attempt was made to record the data as completely as possible in order that maximum use and accurate interpretation of the information obtained might be possible. A total of 330 returned questionnaires were tabulated. A total of 13 returned questionnaires came in too late for tabulation.

The data are recorded in the accompanying Tables I to VI and the charts in Figs. 1 to 4. Each question is reproduced in the tables, exactly as it appeared in the questionnaire.

DISCUSSION OF DATA

It will be noted from Table I that the number of returned questionnaires from producers is about equal to the number of returned questionnaires from consumers plus general interests. The same approximate division also holds for those that use accelerated tests. Approximately 70 per cent of those who returned questionnaires indicated that they use accelerated tests. The types of paint coatings tested are approximately equally divided between industrial and maintenance paints with a small proportion of other paint coatings. Typical "other paint coatings" are artists' paints, floor enamels, paper and textile coatings, and lithograph and metal sign coatings.

The information summarized in Table II and Figs. 1 and 2 shows the frequency of use of the various tests. It is

TABLE I.—CLASSIFICATION OF INTERESTS OF THOSE WHO RETURNED QUESTIONNAIRES, AND TYPES OF COATINGS TESTED.

	Producers[a]	Consumers[b]	General Interests[c]
Question 1:			
What are your interests?[d]	155	142	51
Question 2:			
Do you test:[e]	125	90	30
Maintenance paint coatings?	102	92	28
Industrial paint coatings?	121	84	25
Other paint coatings?	20	18	6

[a] Producers of paints or of paint raw materials.
[b] Consumers of paints.
[c] Independent engineers, educators, and persons who are neither producers nor consumers.
[d] The number of individual returns recorded was 330. Some returns stated that their interests were in more than one field.
[e] Any accelerated tests on paint coatings.

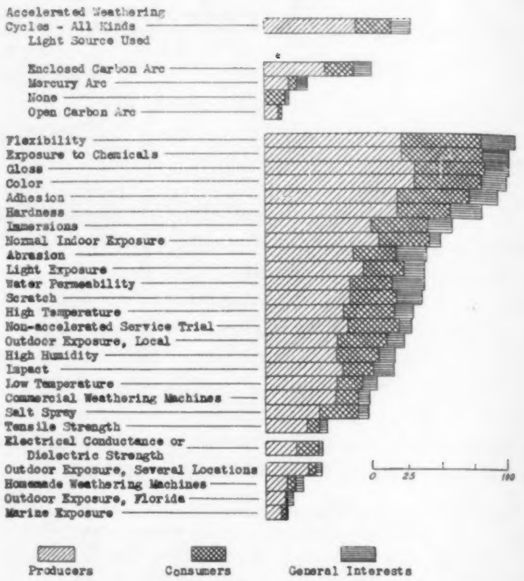


Fig. 1.—Summary of Tests Employed in Testing Paint Coatings for Indoor Use (see Table II).

evident that local outdoor weathering exposure is more widely used than commercial weathering machines and that more than half of those who returned the questionnaires use outdoor weathering for testing paint coatings intended for outdoor use.

It is evident from Table III and Fig. 3 that the majority of those who expressed opinions do not believe that commercial weathering machines and accelerated weathering cycles satisfactorily evaluate the ability of paint coatings to withstand indoor and outdoor weathering. The "don't know" answers are in the majority and an analysis of their source indicates that producers have much more positive opinions on accelerated weathering than do either consumer or general interest groups. This may be due to the fact that producers have more commercial weathering machines than do the consumer or general interest groups.

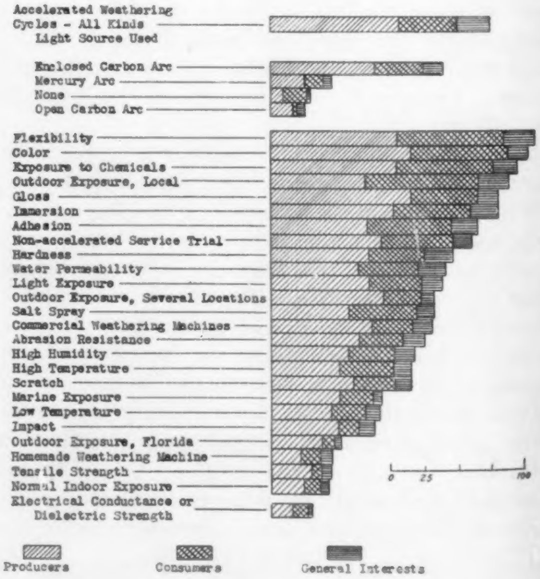


Fig. 2.—Summary of Tests Employed in Testing Paint Coatings for Outdoor Use (see Table II).

TABLE II.—TESTS EMPLOYED IN ACCELERATED TESTING OF PAINT COATINGS.

QUESTION 3: How Do You Test?	Tested by Producers						Tested by Consumers						Tested by General Interests						Grand Total
	Maintenance	Industrial	Combination[a]	Other	Not Stated	Total	Maintenance	Industrial	Combination[a]	Other	Not Stated	Total	Maintenance	Industrial	Combination[a]	Other	Not Stated	Total	
PAINT COATINGS FOR INDOOR USE																			
Outdoor exposure: Local only	1	7	36	3	5	52	8	5	22	..	1	36	2	1	7	1	2	13	101
Florida only	1	1	11	..	..	13	..	..	2	..	..	2	1	..	3	..	..	4	19
Several locations	2	6	22	..	1	31	..	1	4	..	..	5	..	1	3	..	..	4	40
Accelerated Weathering Cycles (Including commercial weathering machines, homemade weathering machines, or a combination of environments employing separate conditioning units such as ovens, cabinets, cook boxes, etc.)	1	11	48	2	4	66	4	5	12	1	2	24	1	1	8	1	2	13	103
Light source used for accelerated weathering cycles:																			
Mercury arc	..	5	11	1	..	17	1	2	4	..	..	6	1	1	4	..	2	8	31
Enclosed carbon arc	1	7	32	1	2	43	3	5	11	2	1	22	2	..	7	2	2	13	78
Open carbon arc	..	1	6	..	2	9	..	..	2	..	..	2	..	..	..	..	..	..	11
None	..	..	..	..	..	..	3	1	9	..	..	13	1	1	..	..	2	4	17
Commercial weathering machines	1	8	37	2	3	51	3	4	8	1	1	17	..	..	6	..	2	8	76
Homemade weathering machines	..	3	11	..	1	15	1	1	4	..	1	7	1	1	2	1	..	5	27
Normal indoor exposure	5	14	57	..	6	82	5	7	24	..	1	37	..	..	6	1	2	9	128
Nonaccelerated service trial exposures	2	11	45	..	2	60	8	10	16	2	1	37	2	1	7	..	..	10	107
Marine exposure	..	2	9	..	..	11	..	1	1	1	..	3	..	..	1	..	..	1	15
High humidity exposure	..	11	40	..	1	52	3	9	15	3	1	31	1	3	4	1	2	11	94
Salt spray exposure	..	8	29	..	1	38	2	8	14	3	1	28	1	2	3	..	2	8	74
High-temperature exposure	..	13	42	..	2	57	4	8	23	2	..	37	2	1	8	..	3	14	108
Low-temperature exposure	..	12	37	1	1	51	..	6	11	..	1	18	1	..	7	..	2	10	79
Light exposure	1	10	49	2	10	72	..	8	19	1	1	29	2	1	11	..	2	16	117
Immersion tests	2	16	57	..	2	77	5	6	27	3	1	42	3	2	10	..	3	18	137
Exposures to chemicals, including acids, alkalies, salts, solvents, oils, gas, perspiration, etc.	4	17	70	2	6	99	9	12	34	3	2	60	2	2	15	..	2	21	180
Flexibility	3	16	72	2	6	99	11	10	33	3	2	59	4	2	16	1	4	27	185
Adhesion	3	17	70	2	4	96	8	12	30	2	1	53	4	1	14	..	3	22	171
Hardness	3	17	70	2	4	96	2	9	26	1	1	39	5	1	13	1	3	23	158
Abrasion resistance	3	13	43	1	4	64	4	7	20	..	1	32	4	..	15	..	3	22	118
Impact resistance	..	11	41	1	3	56	1	7	11	2	1	22	2	2	8	..	3	15	93
Scratch resistance	1	14	41	1	4	61	2	9	19	2	1	33	3	..	13	1	2	19	113
Tensile strength	..	7	20	1	2	30	..	1	6	1	..	8	..	..	6	..	1	7	45
Gloss	6	18	75	1	9	109	11	10	28	2	1	52	3	..	14	..	2	19	180
Color	6	16	76	2	8	108	12	7	28	2	1	50	3	..	15	..	2	20	178
Water permeability	1	10	47	2	2	62	4	4	19	2	2	31	4	2	14	1	3	24	117
Electrical conductance or dielectric strength	..	6	14	1	1	22	1	3	13	..	..	17	..	1	1	..	..	2	41
PAINT COATINGS FOR OUTDOOR USE																			
Outdoor exposure: Local only	5	10	46	3	4	68	19	11	40	5	8	83	5	1	12	1	4	23	174
Florida only	2	4	25	2	3	36	1	2	6	..	..	9	..	..	5	..	..	5	50
Several locations	4	11	60	..	7	82	5	3	18	..	..	26	..	1	8	..	1	10	118
Accelerated Weathering Cycles (Including commercial weathering machines, homemade weathering machines, or a combination of environments employing separate conditioning units such as ovens, cabinets, cook boxes, etc.)	5	15	67	3	4	94	11	5	26	1	..	43	4	1	17	..	2	24	161
Light source used for accelerated weathering cycles:																			
Mercury arc	..	6	16	1	..	23	3	1	9	..	..	13	1	..	4	..	2	7	43
Enclosed carbon arc	5	8	55	2	5	75	9	4	19	2	..	35	4	..	10	..	1	15	125
Open carbon arc	..	1	14	..	1	16	..	..	2	..	..	2	..	..	4	..	2	6	24
None	..	2	5	..	1	8	4	3	11	..	..	18	1	1	..	..	..	2	28
Commercial weathering machines	3	10	55	2	3	73	6	4	18	1	..	29	3	..	11	..	1	15	117
Homemade weathering machines	2	5	12	1	1	21	5	1	8	..	..	14	1	1	6	..	1	9	44
Normal indoor exposure	1	5	14	..	3	23	3	2	6	..	1	12	..	..	4	..	2	6	41
Nonaccelerated service trial exposures	5	15	53	..	6	79	15	7	25	3	3	53	3	1	8	1	1	14	146
Marine exposure	1	5	43	..	..	49	6	3	14	2	..	25	1	..	5	..	..	6	80
High humidity exposure	..	12	44	..	1	57	5	5	20	2	..	32	1	2	9	1	2	15	104
Salt spray exposure	..	10	45	..	1	56	6	8	31	3	1	49	2	2	6	..	3	13	118
High-temperature exposure	1	11	35	..	2	49	5	5	28	1	..	39	2	1	8	1	2	14	102
Low-temperature exposure	..	12	29	1	1	43	2	3	20	..	..	25	1	..	7	1	2	11	79
Light exposure	4	10	51	1	5	71	7	5	24	..	1	37	2	1	11	..	2	16	124
Immersion tests	4	16	65	..	3	88	11	6	37	2	1	57	3	2	14	..	2	21	166
Exposure to chemicals, including acids, alkalies, salts, solvents, oils, gas, perspiration, etc.	5	13	67	..	6	91	13	7	45	3	3	71	2	2	13	1	1	19	181
Flexibility	5	16	67	..	4	92	21	10	39	5	3	78	5	3	15	..	3	26	196
Adhesion	3	16	47	..	4	70	13	12	30	2	4	61	4	2	13	..	1	20	151
Hardness	3	16	48	..	4	71	6	7	24	1	2	40	4	2	12	..	3	21	132
Abrasion resistance	5	11	45	..	3	64	9	4	15	2	1	31	4	..	11	..	2	17	112
Impact resistance	..	11	34	..	3	48	2	5	9	..	..	16	2	2	5	..	2	11	75
Scratch resistance	1	13	41	..	4	59	4	7	18	1	..	30	3	..	9	..	1	13	102
Tensile strength	1	5	21	..	2	29	..	..	6	..	1	7	..	..	6	..	1	7	43
Gloss	3	17	73	1	7	101	15	9	20	2	3	49	3	..	12	..	1	16	166
Color	5	17	73	1	6	102	22	6	36	3	4	71	3	..	12	..	2	17	190
Water permeability	2	9	48	1	3	63	8	7	25	3	..	43	4	2	12	1	2	21	127
Electrical conductance or dielectric strength	..	4	9	1	1	15	1	1	9	..	..	11	1	1	1	..	..	3	29

[a] Tests on two or more types of paint coatings, nearly all are a combination of maintenance and industrial paint coatings.

TABLE III.—OPINIONS ON COMMERCIAL WEATHERING MACHINES AND ACCELERATED WEATHERING CYCLES.

	Paint Coatings Tested by Producers						Paint Coatings Tested by Consumers						Paint Coatings Tested by General Interests						Paint Coatings Tested by Combination Viewpoint[c]						Grand Total
	Maintenance	Industrial	Combination[b]	Other	Not Stated	Total	Maintenance	Industrial	Combination[b]	Other	Not Stated	Total	Maintenance	Industrial	Combination[b]	Other	Not Stated	Total	Maintenance	Industrial	Combination[b]	Other	Not Stated	Total	
Opinions Expressed on Ability to Evaluate Paint Coatings																									
Question 4a:																									
Do commercial weathering machines satisfactorily evaluate the ability of paint coatings to withstand outdoor weathering?																									
Yes	..	1	9	..	1	11	4	1	6	..	1	12	..	..	3	..	..	3	..	..	2	..	..	3	29
Qualified Yes[a]	..	1	6	..	..	7	3	..	2	..	..	5	2	..	2	..	..	4	..	..	1	..	..	1	17
No	3	9	39	1	6	58	4	3	17	2	1	27	1	1	4	..	1	7	2	3	4	..	1	10	102
Don't Know	1	6	19	1	5	32	14	8	15	4	12	53	2	2	8	1	7	20	1	1	7	..	..	9	114
Do commercial weathering machines satisfactorily evaluate the ability of paint coatings to withstand indoor weathering?																									
Yes	..	..	5	..	1	6	..	1	3	..	..	4	..	1	3	..	..	4	..	..	..	..	..	..	14
Qualified Yes[a]	..	..	3	..	..	3	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	4
No	1	6	26	..	1	34	..	3	11	..	1	15	..	..	1	..	..	1	..	2	2	..	1	5	55
Don't Know	3	6	27	2	9	47	15	7	24	3	13	62	3	1	8	1	10	23	3	1	9	..	..	13	145
Do any other types of accelerated weathering cycles satisfactorily evaluate the ability of paint coatings to withstand outdoor weathering?																									
Yes	1	3	8	..	..	12	2	1	7	..	..	10	..	1	2	..	2	5	..	..	2	..	..	2	29
Qualified Yes[a]	..	..	3	..	..	3	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..	..	4
No	..	9	21	..	1	31	..	3	9	..	1	13	1	..	3	..	1	5	..	1	4	..	..	5	54
Don't Know	2	5	35	2	10	54	17	9	23	6	14	69	4	2	11	1	6	24	4	2	7	..	..	13	160
Do any other types of accelerated weathering cycles satisfactorily evaluate the ability of paint coatings to withstand indoor weathering?																									
Yes	..	3	6	..	..	9	..	1	..	..	1	4	..	1	2	..	2	5	..	1	1	..	..	2	20
Qualified Yes[a]	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
No	..	4	9	..	..	13	..	3	5	..	..	8	..	..	1	..	..	1	2	1	2	..	..	5	27
Don't Know	2	5	38	2	9	56	15	7	29	4	15	70	4	1	9	1	7	22	2	1	8	..	..	11	159
Opinions Expressed on Future Development																									
Question 4b:																									
In your experience, are the results obtained by commercial weathering machines in the evaluation of the ability of paint coatings to withstand outdoor weathering sufficiently promising to warrant further development leading toward their standardization?																									
Yes	3	7	62	2	2	76	8	1	23	2	3	37	3	1	11	..	3	18	2	2	10	..	1	15	146
Qualified Yes[a]	..	..	2	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
No	..	4	7	..	..	11	2	..	6	..	..	8	1	..	2	..	..	3	..	..	..	..	..	..	22
Don't Know	1	6	9	1	10	27	14	12	13	4	12	55	..	1	2	1	6	10	1	1	3	..	..	5	97
In your experience, are the results obtained by commercial weathering machines in the evaluation of the ability of paint coatings to withstand indoor weathering sufficiently promising to warrant further development leading toward their standardization?																									
Yes	1	3	43	..	1	48	1	2	11	1	2	17	2	1	7	1	1	12	..	2	4	..	..	6	83
Qualified Yes[a]	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
No	..	3	2	..	..	5	..	..	5	..	1	6	..	1	..	..	..	1	..	..	..	..	..	..	12
Don't Know	1	8	9	2	8	28	12	10	15	2	12	51	1	..	7	..	6	14	2	1	6	..	..	9	102
Are the results obtained by any other types of accelerated weathering cycles in the evaluation of the ability of paint coatings to withstand outdoor weathering sufficiently promising to warrant further development leading toward their standardization?																									
Yes	..	5	36	..	3	44	1	2	15	..	..	18	..	1	7	..	1	9	3	..	3	..	1	7	78
Qualified Yes[a]	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
No	..	2	2	..	..	4	..	1	2	..	..	3	1	..	1	..	..	2	..	1	1	..	..	2	11
Don't Know	2	8	32	2	7	51	15	7	19	4	12	57	4	1	3	1	7	16	..	2	10	..	..	12	136
Are the results obtained by any other types of accelerated weathering cycles in the evaluation of the ability of paint coatings to withstand indoor weathering sufficiently promising to warrant further development leading toward their standardization?																									
Yes	..	3	26	..	..	29	..	3	7	..	1	11	..	1	5	..	..	6	2	1	..	..	..	3	49
Qualified Yes[a]	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	...
No	..	1	..	..	..	1	..	..	2	..	..	2	..	..	1	..	..	1	..	1	..	..	..	1	5
Don't Know	3	9	13	2	9	36	16	7	26	4	14	67	4	2	8	1	8	23	..	1	10	..	1	12	138

[a] Satisfactory only for comparison of identical materials or for disclosing a particular type of failure.
[b] Tests on two or more types of paint coatings; nearly all are a combination of maintenance and industrial paint coatings.
[c] Testers who classify themselves as having more than one interest.

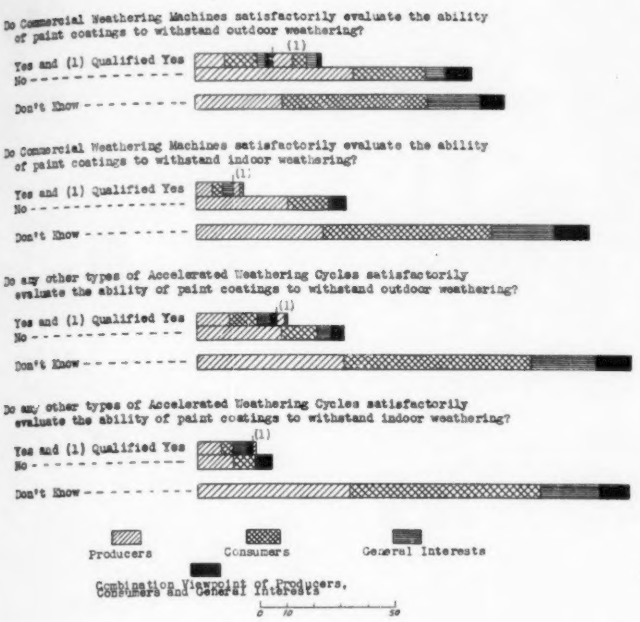


Fig. 3.—Summary of Opinions on Commercial Weathering Machines and Accelerated Weathering Cycles (see Table III).

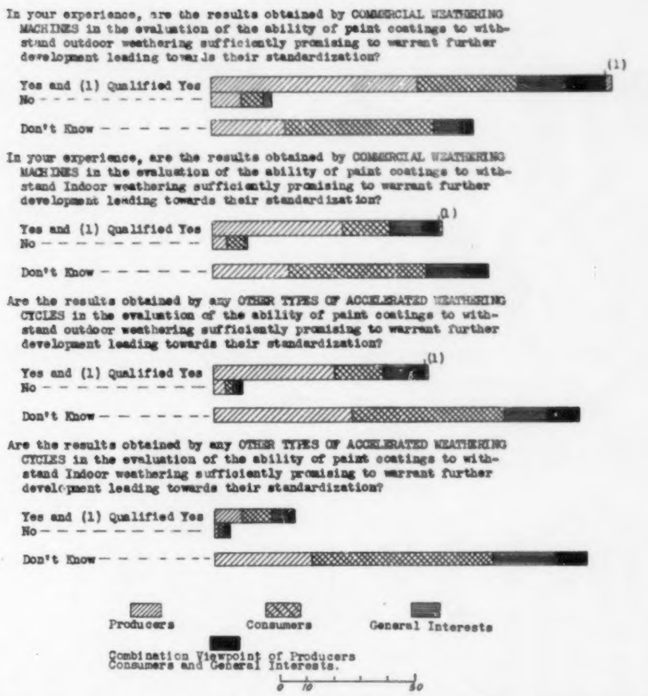


Fig. 4.—Summary of Opinions on the Future Development of Commercial Weathering Machines and Accelerated Weathering Cycles (see Table III).

TABLE IV.—OPINIONS OF USERS AND NONUSERS OF WEATHERING MACHINES AND ACCELERATED WEATHERING CYCLES.

	Replies from All Interests Who Have Either				Replies from All Interests Who Do Not Use Weathering Machines	Total
	Commercial Weathering Machines	Homemade Weathering Machines	Commercial and Homemade Weathering Machines	Total		
QUESTION 4a:						
Do commercial weathering machines satisfactorily evaluate the ability of paint coatings to withstand outdoor weathering?						
Yes and Qualified Yes[a]	34	1	1	36	10	46
No	37	11	5	53	49	102
Don't Know	19	16	...	35	79	114
Do commercial weathering machines satisfactorily evaluate the ability of paint coatings to withstand indoor weathering?						
Yes and Qualified Yes[a]	12	1	...	13	5	18
No	23	8	2	33	22	55
Don't Know	26	16	3	45	100	145
Do any other tests of accelerated weathering cycles satisfactorily evaluate the ability of paint coatings to withstand outdoor weathering?						
Yes and Qualified Yes[a]	14	7	2	23	10	33
No	23	8	1	32	22	54
Don't Know	44	15	3	62	98	160
Do any other types of accelerated weathering cycles satisfactorily evaluate the ability of paint coatings to withstand indoor weathering?						
Yes and Qualified Yes[a]	6	4	...	10	11	21
No	10	6	1	17	10	27
Don't Know	43	15	5	63	96	159
QUESTION 4b:						
In your experience, are the results obtained by commercial weathering machines in the evaluation of the ability of paint coatings to withstand outdoor weathering sufficiently promising to warrant further development leading toward their standardization?						
Yes and Qualified Yes[a]	73	17	6	96	52	148
No	9	5	...	14	8	22
Don't Know	10	7	1	18	79	97
In your experience, are the results obtained by commercial weathering machines in the evaluation of the ability of paint coatings to withstand indoor weathering sufficiently promising to warrant further development leading toward their standardization?						
Yes and Qualified Yes[a]	41	10	2	53	31	84
No	4	2	...	6	6	12
Don't Know	19	13	3	35	67	102
Are the results obtained by any other types of accelerated weathering cycles in the evaluation of the ability of paint coatings to withstand outdoor weathering sufficiently promising to warrant further development leading toward their standardization?						
Yes and Qualified Yes[a]	28	15	2	45	34	79
No	6	2	...	8	3	11
Don't Know	37	6	1	44	92	136
Are the results obtained by any other types of accelerated weathering cycles in the evaluation of the ability of paint coatings to withstand indoor weathering sufficiently promising to warrant further development leading toward their standardization?						
Yes and Qualified Yes[a]	18	14	1	33	16	49
No	4	...	...	4	1	5
Don't Know	40	10	4	54	84	138

[a] Satisfactory only for comparison of identical materials or for disclosing a particular type of failure.

TABLE V.—OPINIONS EXPRESSED AS TO THE ORDER OF PREFE

QUESTION 5: Granted that the method of conducting outdoor exposure tests should be standardized for various outdoor exposure test. In your opinion which phases of outdoor exposure test should the committee st

		First Choice for Standardization: Types of Paint Coating Tested						Second Choice for Standardization: Types of Paint Coating Tested				
		Maintenance	Industrial	Combination[b]	Other	Not Stated	Total	Maintenance	Industrial	Combination[b]	Other	Not Stated
Panel, nature and size	Producer	..	3	14	..	3	20	..	3	12	..	2
	Consumer	6	1	5	1	3	16	9	1	11	2	2
	General Interest	1	..	3	..	2	6	1	2	4	..	1
	Comb. Viewpoint[a]	2	1	4	..	..	7	1	1	1	..	..
	Total	9	5	26	1	8	49	11	7	28	2	5
Coating, application and thickness	Producer	1	7	23	..	..	31	1	7	25	1	4
	Consumer	13	6	21	2	9	51	6	5	9	1	6
	General Interest	2	3	3	1	4	13	..	1	5	..	2
	Comb. Viewpoint[a]	1	1	5	..	3	10	1	2	4	..	1
	Total	17	17	52	3	16	105	8	15	43	2	13
Panel mounting, slope, direction	Producer	..	2	18	..	7	27	..	1	22	1	3
	Consumer	2	1	6	1	2	12	5	2	9	..	2
	General Interest	..	..	5	..	..	5	1	1	1	..	2
	Comb. Viewpoint[a]	..	..	..	..	1	1	1	..	3	..	..
	Total	2	3	29	1	10	45	7	4	35	1	7
Measurement and recording of meteorological conditions	Producer	..	1	3	1	4	9	..	2	13	1	..
	Consumer	..	1	1	..	1	3	3	1	2	2	2
	General Interest	..	1	..	..	..	1		1	3	..	2
	Comb. Viewpoint[a]	..	2	..	..	..	2	1	..	2	..	..
	Total	..	5	4	1	5	15	[illegible]	4	20	3	4
Division of country into zones in any one of which approximately equal exposure conditions exist	Producer	1	2	9	..	6	18	2	2	11	1	1
	Consumer	1	1	2	2	1	7	2	2	5	1	1
	General Interest	1	..	4	..	..	5	..	..	2	..	1
	Comb. Viewpoint[a]	1	..	1	..	..	2	..	..	..	..	..
	Total	4	3	16	2	7	32	4	4	18	2	3
Definition of failure characteristics such as checking, chalking, rusting, etc.	Producer	2	8	19	2	6	37	2	3	15	..	4
	Consumer	6	4	11	2	3	26	2	1	9	..	5
	General Interest	..	..	7	..	4	11	1	..	3	1	1
	Comb. Viewpoint[a]	3	1	3	..	..	7	..	1	2	..	..
	Total	11	13	40	4	13	81	5	5	29	1	10

[a] Testers who classify themselves as having more than one interest, that is, interested in testing paint coatings due to a combination viewpoint of pr

[b] Test on two or more types of paint coatings; nearly all are a combination of maintenance and industrial paint coatings.

Despite the majority opinion, there are a considerable number of testers employing weathering machines and accelerated cycles who have confidence in the reliability of the results obtained by their methods. This fact should be of particular interest in the event that further investigation leading toward standardization of an accelerated weathering test is undertaken.

As shown in Table III and Fig. 4, the consensus is very optimistic regarding the possibilities of developing a commercial weathering machine and accelerated weathering cycles to evaluate satisfactorily the durability of both indoor and outdoor paint coatings. However, the "don't know" answers indicate a greater skepticism relative to the development of the accelerated weathering cycles than to the development of commercial weathering machines. Producers seem to be more positive as to the future of commercial weathering machines and accelerated weathering cycles. The small number of qualified "yes" answers noted in reply to this question may forecast greater certainty concerning the exact reproduction of normal weathering, when and if commercial weathering machines and accelerated weathering cycles are fully developed.

Table IV contains a more detailed breakdown of the data (presented in Table III) obtained from questions 4a and 4b and shows the differences of opinion that exist between users and nonusers of weathering machines relative to the satisfactory evaluation of paint coatings by means of commercial weathering machines and accelerated weathering cycles and the possibilities of their standardization at some future time. The larger number of "don't know" answers expressed by nonusers of weathering machines show that there are many nonusers not sufficiently acquainted with weathering machines to express a positive opinion.

The order of interest in the several steps involved in the making of outdoor exposure tests is self evident from the information given in Tables V and VI and requires no further explanation.

Testing Devices Applicable to Paint Coatings

The following is in answer to question 6 and is a list of testing machines, devices, or procedures used for testing materials other than paint coatings and which might be applicable to the testing of paint coatings:

1. Erichsen or Olsen draw tester for deep drawing tests,

2. U. S. Dorry hardness machine for abrasion resistance, and

3. Mullen tester for flexibility of paint coatings applied to a proper surface.

Conclusions

The objectives of this study as outlined in the forepart of this report have been successfully completed and on the basis of the returns of the questionnaire, the following conclusions have been drawn:

... THE STANDARDIZATION OF OUTDOOR EXPOSURE TESTS.

...ns, it would be necessary to carefully consider the standardization of each step in the process of making an ... Please indicate your preference by numbering the items, 1 (most important), 2 (less important), etc.

...ird Choice for Standardization — Type of Paint Coating Tested					Fourth Choice for Standardization — Type of Paint Coating Tested						Fifth Choice for Standardization — Type of Paint Coating Tested						Sixth Choice for Standardization — Type of Paint Coating Tested					
Industrial	Combination[b]	Other	Not Stated	Total	Maintenance	Industrial	Combination[b]	Other	Not Stated	Total	Maintenance	Industrial	Combination[b]	Other	Not Stated	Total	Maintenance	Industrial	Combination[b]	Other	Not Stated	Total
3	15	1	3	24	2	1	7	1	2	13	1	2	9	1	2	15	1	1	14	..	3	19
2	6	1	4	14	4	3	7	1	1	16	1	2	4	1	2	10	4	..	7	..	..	11
..	4	..	..	6	..	..	2	..	1	3	..	1	1	1	4	7	..	..	3	..	2	5
1	1	..	1	3	..	..	2	..	..	2	..	1	2	..	..	3	2	1	3	..	..	6
6	26	2	8	47	6	4	18	2	4	34	2	6	16	3	8	35	7	2	27	..	5	41
..	9	1	1	11	2	..	11	..	2	15	..	..	5	..	..	5	..	..	3	..	..	3
..	6	1	1	10	1	1	2	1	2	7	..	..	..	..	..	..	..	..	1	..	..	1
..	5	..	4	9	..	..	2	..	2	4	1	..	..	..	..	1	..	..	..	..	..	..
..	2	..	..	2	..	1	1	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..
..	22	2	6	32	3	2	16	1	6	28	1	..	5	..	..	6	..	..	4	..	..	4
6	18	..	..	27	1	..	10	..	3	14	1	2	2	..	1	6	..	1	1	..	..	2
1	15	2	5	33	4	4	8	..	5	21	2	2	4	2	..	10	..	1	..	1	..	2
1	2	..	3	8	1	1	4	..	3	9	..	..	2	..	1	3	..	..	..	1	..	1
1	5	..	..	6	1	2	2	..	..	5	1	2	2	..	..	5	..	..	..	..	..	..
9	40	2	8	74	7	7	24	..	11	49	4	6	10	2	2	24	..	2	1	2	..	5
1	9	..	1	11	..	..	6	..	1	7	3	2	11	..	4	20	2	6	17	..	2	27
2	6	..	1	13	2	..	5	..	2	9	4	3	11	1	5	24	6	3	10	2	3	24
..	1	..	..	1	..	1	2	1	2	6	1	..	3	..	4	8	2	..	6	..	2	10
..	..	..	..	..	..	..	2	..	..	2	2	1	4	..	..	7	..	1	2	..	1	4
3	16	..	2	25	2	1	15	1	5	24	10	6	29	1	13	59	10	10	35	2	8	65
1	13	..	3	17	..	..	13	2	2	17	..	2	21	..	..	23	1	2	5	..	1	9
2	2	..	1	6	1	..	7	1	1	10	9	1	8	..	3	21	5	3	11	1	5	25
1	1	1	..	3	..	..	1	..	1	2	..	..	5	..	1	6	2	1	1	..	4	8
1	3	..	..	6	..	1	1	..	1	3	..	1	4	..	..	5	..	1	2	..	..	3
5	19	1	4	32	1	1	22	3	5	32	9	4	38	..	4	45	8	7	19	1	10	45
2	8	1	3	14	1	..	13	..	1	15	..	3	8	..	2	13	..	..	2	..	1	3
2	7	1	1	14	9	1	8	1	1	20	2	..	6	..	1	9	2	1	1	..	1	5
2	2	..	3	7	3	..	3	..	1	7	..	1	1	..	..	2	..	..	1	..	..	1
1	1	..	..	2	..	1	4	..	..	5	..	..	..	..	1	1	..	1	2	..	..	3
7	18	2	7	37	13	2	28	1	3	47	2	4	15	..	4	25	2	[illegible]	6	..	2	12

...sumer, or general interest.

1. The interest and extent of use of accelerated testing have been determined. Over 70 per cent of those who returned the questionnaire use some form of accelerated testing. The 34 per cent response is a measure of the large interest in the subject.

2. The frequency of use of various accelerated and nonaccelerated tests for the properties that indicate service qualities of organic coatings has been determined.

3. While the majority of testers indicate that no commercial weathering machines or accelerated weathering cycles are now available for accurately evaluating durability of paint coatings for indoor and outdoor use, there are, however, a number of testers employing such methods who are confident that reliable results are obtained. It would appear desirable to contact these testers in the event that further study is given to the standardization of accelerated weathering tests.

4. The majority of those who returned questionnaires believe that the results obtained by commercial weathering machines and accelerated weathering cycles show sufficient promise to warrant continuing with their development and standardization.

5. The order of importance for the several steps involved in the process of making outdoor exposure tests with the ultimate view of standardizing such steps has been determined.

TABLE VI.—SUMMARY OF OPINIONS EXPRESSED AS TO ORDER OF PREFERENCE FOR THE STANDARDIZATION OF OUTDOOR EXPOSURE TESTS.

QUESTION 5: Granted that the method of conducting outdoor exposure tests should be standardized for various use classifications, it would be necessary to carefully consider the standardization of each step in the process of making an outdoor exposure test. In your opinion which phases of outdoor exposure tests should the committee standardize first? Please indicate your preference by numbering the items, 1 (most important), 2 (less important), etc.

	Averages[a]	Order of Preference, For All Replies, Grouping All Paint Coatings Tested and All Interests Together							
		1	2	3	4	5	6	Total of Weighted Grand Average	Order of Preference 1 (most important), 2 (less important), etc.
Panel, nature and size	Grand Avg.	49	53	47	34	35	41		
	Weighted Grand Avg.	49	106	141	136	175	246	853	5
Coating, application and thickness	Grand Avg.	105	81	32	28	6	4		
	Weighted Grand Avg.	105	162	96	112	30	24	529	1
Panel mounting, slope, direction	Grand Avg.	45	54	74	49	24	5		
	Weighted Grand Avg.	45	108	222	196	120	30	721	3
Measurement and recording of meteorological conditions	Grand Avg.	15	35	25	24	59	65		
	Weighted Grand Avg.	15	70	75	96	295	390	941	6
Division of country into zones in any one of which approximately equal exposure conditions exist	Grand Avg.	32	31	32	32	45	45		
	Weighted Grand Avg.	32	62	96	128	225	270	813	4
Definition of failure characteristics such as checking, chalking, rusting, etc.	Grand Avg.	81	50	37	47	25	12		
	Weighted Grand Avg.	81	100	111	188	125	72	677	2

[a] Grand average is average of all paint coatings tested by all interests; weighted grand average is obtained by multiplying First Choice by 1, Second Choice by 2, Third Choice by 3, Fourth Choice by 4, Fifth Choice by 5, and Sixth Choice by 6.

APPENDIX

Comments Received in Connection with the Questionnaire on the Accelerated Testing of Paint Coatings

In answering question 4 I have taken "ability to withstand weathering" as meaning durability. I am dubious of accelerated tests, as measured, for durability. They are definitely more valuable for predicting specific types of failure such as chalking, loss of gloss, and fading, etc.

* * *

From many years of experience I conclude that conditions of scale and corrosion growth on so-called standard panels do not represent conditions on rolled shapes or plates.

* * *

No single accelerated test will evaluate a paint coating for outdoor exposure. A wisely chosen series of accelerated tests will sort out those coatings which are good from those which are bad.

* * *

In our opinion there is a definite need for a standard Weatherometer.

* * *

There is a need for standardized check coating for each service for checking all test coatings against.

* * *

We consider accelerated testing devices to be valuable tools for specialized research on paint problems but we do not consider them at all suitable for the routine testing for serviceableness of house paints or exterior woodwork. As a specialized tool for investigating individual factors that alter the physical properties of coatings the accelerated testing procedure should not be too highly standardized because a flexibility for readjustment to requirements of varying special problems should be maintained. Even in normal outdoor exposure tests such factors as nature and size of panels, application and thickness of coating, and method of mounting panels cannot always be rigidly standardized because appropriate changes must often be made according to the objectives of individual tests. Certain of these items such as application and thickness of coating could not be standardized for testing purposes unless the industry were willing to accept some arbitrary standards for the recommended use of house paints and the paint properties necessary to justify the recommendations. On the other hand, there is undoubtedly room for standardizing definitions of failure characteristics of paint coatings provided this is done in a thoroughly logical manner that can be accepted by individual research workers. Some of the present A.S.T.M. definitions of terms are not accurate enough for general acceptance. More important, however, than the mere standardization of individual terms is the coordination of individual factors of paint weathering into an acceptable evaluation of the serviceableness of the coatings. Our procedure with respect to this point has been published in detail in the A.S.T.M. *Proceedings*,[4] and our ideas of paint testing, in general, were discussed in the *Journal of Chemical Education*, Vol. 10, p. 559 (1933).

* * *

As far as we have observed, accelerated weathering cycles are not very useful. We find that a 45-deg. angle mounting during summer months is very effective and accelerates weathering several times.

* * *

We carry out immersion tests in large tanks placed outdoors and the test panels are mounted in racks which are completely immersed in the water for a period of 5 min. and then raised and left to drain and dry for a period of 25 min. This gives two complete cycles per hour. Such a test has been found useful in developing painting systems for aluminum, magnesium, and steel, to mention particular metals with which we have had experience. With regard to commercial weathering machines we have checked both "yes" and "no" to the question, "Do commercial measuring machines satisfactorily evaluate the conditions of paint coatings to withstand outside weathering?" In explanation, we would say that such experience as we have had with the Weatherometer indicates that the equipment can be used for the comparison of similar types of coatings where the general behavior outdoors is understood. In general, however, we rely very little on this machine except for testing lacquers colored with dyes and make most of our weathering tests by outdoor exposure or accelerated exposure in the alternate immersion tanks just described.

* * *

In a project on air drying lacquers formulated with cellulose derivatives and synthetic resins we are using the accelerated weathering method described in the enclosed reprint. This method has been modified now to place the source of light 6 in. above the plane of the samples. The greater intensity of the light thus obtained reduces the time of the test from 500 hr. to 200 hr. The advantage of using a mist or dew chamber in place of the water-spray technique generally employed in commercial weathering machines is described in the reprint.[5] It is also adequately covered in a paper by R. J. Wirshing, on "Some Causes of Failure of Paint Films."[6] It is our belief that an accelerated weathering method based on a source of ultra-violet light closely resembling sunlight in a cycle involving contact with droplets of moisture is sufficiently promising to warrant an investigation on the testing of paint coatings.

* * *

So far we have found that the only reliable method of checking an automotive finishing system for durability is actual usage. However, we find that test panels, when duplicates are exposed at Fort Lauderdale, Fla., and Detroit, Mich., are fairly reliable indicators when interpreted in the light of previous experience. I have found all efforts at acceleration beyond actual exposure to give results which at times are definitely in direct opposition to exposure data. In the light of the above experience, our method of operation is as follows: When we have established a formula as having desired durability by exposure panels in actual test cars, we then use various tests as checked in the questionnaire as comparison tests on new batches of material to be sure the new material is up to standard. I have found that physical tests are of no value in comparing two finishing systems of different composition. Such tests often give results which indicate that they are of value but they are so often absolutely wrong that no reliance can be placed in them in the absence of actual usage or panel exposure. In respect to interior finishing systems I believe that accelerated tests have some value. Oftentimes life results can be accurately predicted if the exact usage is known. Here again, however, accelerated tests become more unreliable in direct ratio to the degree of acceleration. My suggestion is that the committee seriously consider the adoption of accelerated tests only as comparisons for previously approved standards.

* * *

We consider that coatings should be checked in the manner and system they will be later used in, that is, prime, underfinished coat, over bare metal (steel, aluminum, magnesium, etc.), dried as used.

* * *

There is a need for some method of calibrating ultra-violet lights in terms of average noonday sunlight for 30 deg., 35 deg., 40 deg., 45 deg., north (south) latitude. Most values given are not much more than mere guesswork.

* * *

On some products we find materially greater weathering when panels have their slope northerly than if their slope is southerly. On our exposure farm the majority of our panels slope to the southeast.

* * *

Perhaps because its spectrum does not resemble that of sunlight the mercury vapor lamp has been passed up in favor of the carbon arcs, whereas, it gives excellent results on paint coatings, etc.

* * *

We are very much in accord with the continued investigations on the evaluations of organic coatings through accelerated weathering tests. There is definite interest in the possibilities of your committee problem but active interest might have been lagging due to wide differences obtained between laboratories using commercial equipment and, as a matter of fact, it is our impression that differences occur in the same laboratory on the same materials tested at different times. With the rapid progress being made in resin and pigment products, and also in the drying oil fields, we feel that accelerated weathering tests would be of immeasurable value to the consumer in particular if the results obtained could be correlated with actual service tests.

* * *

The entire subject of commercial weathering machines and accelerated weathering cycles is somewhat controversial, to make a qualified statement. Our experience has shown that for certain types of materials this method is valuable and will give reproducible results which can be compared with normal exposure results. However, this does not apply to all types of coating materials. It is the view of our people who have studied this matter that the ultimate solution of this problem depends on developing the test method along the line of the one used in which the rate of change of the various physical properties of the film is studied and reported.

[4] F. L. Browne, "Procedure Used by the Forest Products Laboratory for Evaluating Paint Service on Wood," *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part II, p. 852 (1930).

[5] G. M. Klein, W. A. Crouse, and B. M. Axilrod, "Accelerated Weathering of Transparent Plastics," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 1256 (1940).

[6] Presented at the meeting of the Paint, Varnish, and Plastics Division of Am. Chemical Soc. in Detroit, on September 10, 1940.

I suggest that the nature of the dissolved substances in rain water in various locations be more thoroughly investigated. Substances in suspension might be checked, and pH also.

* * *

We know of no such machine at the present time, but a device which alternately condenses and evaporates moisture from the surface of the panel by means of sharp rises and drops in temperature might more closely parallel outside results than the ultra-violet light cycles.

* * *

More important than any accelerated tests are tests specially devised to meet the conditions under which the material is to be used. In my experience many specifications now used do not meet such requirements.

* * *

In general, we feel that accelerated testing in one form or another is a valuable tool in the paint industry. Our experience indicates, however, that given any one set of conditions for accelerated testing the results obtained under those conditions with any one finish are not necessarily applicable to some other type of finish even though in some cases the composition might be quite similar and it is certainly dangerous if the conclusions are applied to a distinctively different type of formulation. We believe that it may be possible to standardize some form of accelerated weathering which might show reasonably good coordination with outdoor weathering of certain properties. We do not believe that any weathering cycles will ever be developed or can be developed which, as such, will correlate with average outdoor exposures in any one locality for all properties.

* * *

We have made numerous attempts to correlate performance on accelerated tests with performance on exterior exposure and have obtained only fair results. The greatest danger seems to lie in producing failures in accelerated cycles that never occur in exterior exposure or in normal service. This is typified by the checking usually produced in accelerated cabinets where the water spray is used to cool the cabinets while the lamp is on. The fact is that we were able to reproduce the same type of checking by an intermittent water spray combined with South Florida exposure at 30 deg. and 45 deg. to horizontal. We are currently investigating operating the accelerated tester without the water spray. Another example is the abnormal discoloration often produced under mercury vapor lamps. Furthermore, we have noticed that correlations are better for certain types of coatings than for others.

* * *

Inasmuch as accelerated weathering tests vary occasionally and yield results that are diametrically opposite to those obtained by natural exposure we do not place implicit reliance in them. We do not make a final decision until an accelerated test has been confirmed by a natural one. However, accelerated tests are useful for sorting out a group of formulations. Our experience has shown that poor formulations can thus be eliminated.

* * *

Complexity and high cost would be hindrances to a wider use of commercial accelerated weathering machines, even if they did yield valuable information. Cost is especially important to us since we must pay several times as much here as in the States with the added duties, freight, insurance, etc. The complexity is also undesirable for us from the standpoint of securing repair parts which we know by experience involves a delay of three to six months. While these difficulties are of lesser importance in the U.S.A., still many small companies would hesitate long before paying the price at present demanded for commercial weathering machines, and incur the expense for labor, etc., involved in operating them.

I would use accelerated weathering apparatus only for studying certain details, such as the comparison of different pigments in a given vehicle, rather than for determination of ultimate durability. For this purpose I believe that a simple apparatus could be developed and standardized, which would yield very much the same information as the complicated commercial machines. It should be of a type which can be readily constructed by any good mechanic or could be built very cheaply by semi-mass-production methods, by equipment companies. Such an apparatus could be built according to definite specifications with commercially available parts at a price which even the smallest company could afford to pay. I have in mind one such homemade apparatus which can be constructed for less than $25 material cost, which might yield as much *reliable* information as commercial weathering machines.

* * *

The last step (question 5), namely, "Definition of failure characteristics such as checking, chalking, rusting, etc.," is undoubtedly important to the extent that such definition is necessary for expressing accurately what takes place, but to me it has less importance than is usually attributed to it. The great length that some companies go to in recording on individual sheets observations on every panel by attempting to rate numerically the degree of checking, chalking, rusting, etc., and the expression of these results by means of curves appears almost absurd. Such detailed descriptions hardly seem advisable in a standardized procedure because the personal factor in operating degrees of deterioration is very large, although in research of a more or less fundamental nature it may be desirable to record more minutely the various stages of weathering.

Paint coatings are applied for two purposes, namely, protection and decoration. It would seem advisable then, to have standardized tests for determining and expressing these two properties as simply and directly as possible and have wording for describing the condition of the weathered film when repainting is necessary. The three service characteristics of a coating to be established are:

1. The length of time during which the coating gives practically complete protection to the surface to which it is applied;
2. The period over which appearance can be considered as satisfactory; and
3. Type of deterioration with regard to facility of recoating.

Our exposure observations are made with these three points in view. Practically every panel test is a comparison, hence the tests are run in groups of panels, each group being given a number. Instead of recording each panel separately, all the panels of a group are recorded together. The first sheet of each record lists the coatings and gives the general data, type of coating, kind of panel, method of application, exposure conditions, etc., followed by additional sheets showing modifications in compositions, and then the exposure results. Intervals between examinations may be one, three, or even six months, according to the relative durability of the coatings. Observations at each examination are complete to that point, giving rating of each coating, and, very briefly, type of failure, if any. With this system the amount of work is reduced to a minimum, and we believe the results are just as reliable as the complicated records sometimes used. Moreover, the simplified record enables one to see at a glance the status of a series of tests, and to keep clearly in mind the relative merits of different coatings.

* * *

The failure of a paint film is a complex phenomenon, involving physical and chemical changes in the pigment, vehicle, and film as a whole. These changes are at least partially independent, and actuated by such factors as time; temperature and changes in temperature; intensity and distribution of light energy; amount, nature of, and variations in moisture; nature of under-surface; atmosphere; etc. A complete, "practical" test would have to be unreasonably extensive for it would have to cover all probable combinations of these variables over their varying ranges. At the very beginning, we are faced with the difficulty of defining an even approximate "normal" exposure before we can begin to "accelerate" the factors governing deterioration. Assuming we do agree on a "normal," then comes the problem of accelerating the deterioration factors equally for all paint combinations. This is an obvious impossibility, for we know that paint films are not affected to the same degree by increases in radiation, moisture, etc. To illustrate, let us take two paints, both of which have satisfactory moisture resistance under normal conditions, but one of which is more sensitive to excessive moisture than the other. Let us increase the radiation 20 fold. When we increase the moisture effect 20 fold for the moisture sensitive paint, it has been increased less than 20 fold for the other.

This would lead us to the conclusion that accelerated testing alone cannot be depended upon for reliable evidence of weathering. This is, we believe, true as a generality, but fortunately accelerated testing can often be correlated with practical testing under restricted conditions so that valuable information can be obtained. As the paint films being tested become more alike in their characteristics, the reliability of accelerated testing increases until it becomes a very satisfactory instrument for checking the uniformity for the same formulations. As experience is gained in the comparative results obtained on certain types of formulations between accelerated and outdoor exposure, the results on similar formulations on accelerated tests can be evaluated approximately without outdoor exposure. By running control panels of similar type whose weathering characteristics are known, the reliability of the test is further increased.

Summarizing, we do not believe that any universal, standardized accelerated weathering cycle for paints for outside use is likely to be developed which will permit their reliable evaluation for normal conditions of service. Accelerated weathering is an excellent tool only in the hands of experienced users who are continually making comparative tests with outside exposure.

In accelerated weathering tests, we believe that the distribution of light energy should approximate sunlight, and not be much greater than noon summer sun in intensity. This throws out the mercury arc and open carbon arc.

For interior paint work where fading is the form of paint failure to be tested, our work indicates that the enclosed carbon arc gives reliable results.

Except where deterioration is to be carried to the point of complete failure, as in corrosion work, we doubt if slight variations in film thickness are important. In most cases we are concerned with the failure of the outer surface of the paint film only.

It is, of course, very important that the surfaces of the test pieces be uniform. However, any discussion of this phase, or the use of salt sprays, temperature gradients, etc., is too involved to discuss here.

Effects of Sulfur and Antimony on Steam or Valve Bronze Castings[1]

By A. J. Smith[2] and J. W. Bolton[2]

SYNOPSIS

Loss of sources for certain high-quality, low-impurity virgin metals and diminishing sources of supply for higher purity scrap make it advisable to give very careful consideration to the possible effects of increased "impurities." For alloys used at elevated temperatures, impurities effects under conditions of elevated temperatures as well as their influences on room temperature properties as determined in acceptance tests should be ascertained. These effects should also be determined in the case of substitute alloys.

This paper deals with certain effects of sulfur and antimony (individually and combined) on steam or valve bronze, A.S.T.M. Standard Specifications for Steam or Valve Bronze Castings (B 61 – 41)[3] (also known as Navy M-46 B8g, as QQ-B-691a, composition 1, as class 2A of A.S.T.M. Tentative Specifications for Tin-Bronze and Leaded Tin-Bronze Sand Castings (B 143 – 41 T)[4] and of A.S.T.M. Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 41 T)[5]). The ingot specifications limit sulfur to 0.05 per cent maximum, and antimony to 0.20 per cent maximum. The Navy specifications prescribe manufacture from best grade virgin metals and approved scrap, thus implying that the limits of "impurities" should be quite low.

Laboratory studies by The Lunkenheimer Co. indicate that higher percentages of "impurities" may be permissible than are usual or permitted in today's practices, but also that there is an upper limit which should be prescribed to prevent marked diminution of properties at elevated temperatures.

Room temperature and short-time elevated temperature tests at 550 F. suggest that 0.10 per cent sulfur and 0.25 per cent antimony may be permissible in the final cast alloy. At higher percentages, and especially when both of these impurities are above the maximum suggested, there is sufficient degradation to indicate that restrictions should be prescribed. Long-time embrittlement tests have not been run. It is thought (on the basis of other experiences with this type alloy) that the possibility of structural deterioration at temperatures up to 550 F., and with suitable design stresses, is remote.

Tests under foundry operating conditions have not been made. The strength of the metal and its fluidity indicate that density troubles are not likely to occur. Admitting possible subtle changes in characteristics, it is felt that whatever these may be they would be minor in comparison with the major influences of melting, pouring, and gating practices.

In studies on unsoundness in bronze castings, Bolton and Weigand[6] in 1929 investigated the effects of silicon, sulfur, and aluminum on the room temperature physical properties of steam bronze. Aluminum and silicon, even in small amount, were shown to be highly detrimental. The effect of sulfur up to 0.231 per cent was investigated and though even at this composition the room temperature properties were not adversely affected, no data on the effects at elevated temperatures were given.

Shortly after this, Gardner and Saeger[7,8] published results on the effects of impurities in cast red brass (85 per cent copper, 5 per cent tin, 5 per cent lead, 5 per cent zinc, A.S.T.M. Standard Specifications for Composition Brass or Ounce Metal Castings (B 62 – 41)[9]) and showed that neither sulfur up to 0.1 per cent nor iron up to 0.6 per cent injures the properties of this composition. However, they also neglected to show the effects at elevated temperatures.

No data have appeared on the effects of impurities on the physical properties at the maximum service temperatures for which these bronze alloys were designed. Moreover, the foundry practices employed in obtaining results described in these early papers were not such as to yield physical property values comparable with those obtainable with today's better controlled and improved practices.

No limitation on the impurities of sulfur and antimony are included in A.S.T.M. Specifications B 61[3] for castings but are included in the ingot specifications for this material A.S.T.M. Tentative Specifications B 30[5] in which a maximum of 0.05 per cent sulfur and 0.20 per cent antimony is permitted for alloy 2A. The earlier Specification A.S.T.M. B 30 – 36[10] gave maximum limits of 0.08 per cent sulfur and 0.25 per cent antimony, indicating a recent trend toward restriction of the impurity limits.

In actual foundry practices of The Lunkenheimer Co. antimony averages about 0.10 per cent and sulfur about 0.03 per cent, due to rigidly specified raw materials and accurately controlled melting processes.

In view of the lack of accurate knowledge regarding the effects of these impurities, especially at elevated temperatures, The Lukenheimer Co. considered it desirable at this period to make an investigation of the effects.

Materials

For the making of the melts, electrolytic copper from bus bar punchings, electrolytic zinc, electrolytic lead, and Banka tin were used. Initially, remelting ingot of the proper composition was prepared and later impurity-free scrap from earlier heats was substituted for the ingot. The charge consisted of 40 per cent virgin metal and 60 per cent ingot or return. Charges of 20 lb. were used. Phosphor copper was used for deoxidation. On all heats phosphorus in the final analysis was found to be less than 0.02 per cent. Iron by analysis was kept less than 0.03

[1] A communication from The Lunkenheimer Co., dealing with one phase of its research program on the conservation of tin and substitutes for same. Its presentation was sponsored by Committee B-5.

[2] Research Metallurgist, and Director of Metallurgical Research and Testing, respectively, The Lunkenheimer Co., Cincinnati, Ohio.

[3] 1941 Supplement to Book of A.S.T.M. Standards, Part I, p. 159.

[4] *Ibid.*, p. 380.

[5] *Ibid.*, p. 376.

[6] J. W. Bolton and S. A. Weigand, "Effects of Oxidation and Certain Impurities in Bronze," *Transactions*, Am. Inst. Mining and Metallurgical Engrs. (1929).

[7] H. B. Gardner and C. M. Saeger, Jr., "The Effect of Sulfur and Iron on the Physical Properties of Cast Red Brass (85 Cu, 5 Sn, 5 Zn, 5 Pb)," *Proceedings*, Am. Soc. Testing Mats., Vol. 33, Part II, p. 448 (1933).

[8] H. B. Gardner and C. M. Saeger, Jr., "The Effect of Aluminum and of Antimony on Certain Properties of Cast Red Brass," *Transactions*, Am. Foundrymen's Assn., Vol. 47, p. 423 (1939).

[9] 1941 Supplement to Book of A.S.T.M. Standards, Part I, p. 162.

[10] 1936 Book of A.S.T.M. Standards, Part I, p. 538.

TABLE I.—MELTING IN CLAY GRAPHITE CRUCIBLE.

Specimen	Cover	Yield Point, psi.	Tensile Strength, psi.	Elongation, per cent
No. 1.......	Charcoal	18 200	30 100	18.6
No. 2.......	Glass	19 600	34 400	18.8
No. 3.......	Limestone	19 450	37 900	22.8
No. 4.......	Charcoal—CuO	17 700	40 400	35.5

per cent, entering in largely through stirring rod contamination.

Procedure

The first task was to establish a standard foundry practice which would yield superior results in order that effect of foundry practice should not be a factor in these considerations.

All melting was performed in an Ajax Northrup Induction Furnace. Green sand molds were used to produce a specimen to conform with the threaded-end specimen in the A.S.T.M. Tentative Method of Test for Short-Time High-Temperature Tension Tests of Metallic Materials (E 21 - 37 T).[11] This is not an ideally fed specimen and results, while consistent, average somewhat low due to ineffective feeding.

It was first attempted to melt in a clay graphite crucible. Results were variable but on the whole poor. Different coverings were used with results as shown in Table I.

A silica crucible was then substituted. Even with no cover excellent results were obtained. Cleaner pouring resulted with a cover and as most consistent results were obtained with powdered limestone, melting was standardized with this practice.

Effects of Carbon Contamination

Comments on melting practice are not a purpose of this report but certain observations have been made which are significant. In induction melting in a crucible it may be assumed that the only agents which could affect the properties of the metal are the crucible materials and the cover if otherwise clean conditions are maintained. The cover will be any chosen agent and air, more or less constant in composition except as regards water vapor which would vary with the day and hour of melting.

The poor results obtained using a clay graphite crucible would lead one to suspect the graphite, since by changing to a silica crucible, all other conditions remaining the same, excellent bars were cast. Since carbon dioxide is unstable in the presence of carbon at the melting temperatures, carbon monoxide apparently is the offender. This is in direct opposition to the findings of several workers, the most recent of whom are Pearson and Baker,[12] who conclude "Carbon monoxide is only slightly soluble and its presence in molten bronze does not seriously impair the mechanical properties of the castings." However, other researches and the recent work by H. L. Smith[13] prove that carbon contamination may be and often is a source of unsoundness, although the mechanism may be indirect.

[11] 1939 Book of A.S.T.M. Standards, Part I, p. 1254.

[12] T. F. Pearson and W. A. Baker, "Causes of Porosity in Tin Bronze Castings," *Journal*, Inst. Metals, Vol. 67, p. 231 (1941).

[13] H. L. Smith, "Causes of Gas Unsoundness," delivered before the American Foundrymen's Assn., April 20, 1942 (not preprinted).

TABLE II.—STRAIGHT ALLOY—SiO_2 CRUCIBLE.

Specimen	Copper, per cent	Tin, per cent	Zinc, per cent	Lead, per cent	Sulfur, per cent	Yield Point, psi.	Tensile Strength, psi.	Elongation, per cent	Brinell Hardness Number	Temperature, deg Fahr.
No. 5....	88.14	6.14	3.48	1.96	0.002	18 100	42 200	54.1	..	Room
No. 6....	87.80	6.66	3.08	2.17	0.002	18 100	47 100	40.1	57	Room
No. 7....	87.90	6.16	3.66	1.99	0.002	17 800	40 900	50.8	61	Room
No. 8....	88.00	6.00	4.19	1.30	0.002	17 300	40 700	64.3	63	Room
No. 9....	87.66	6.50	3.54	1.80	0.003	13 750	30 900	23.4	..	550
No. 10....	88.10	6.10	3.60	1.91	0.004	13 300	30 600	22.4	65	550

TABLE III.—EFFECT OF SULFUR ON PROPERTIES AT ROOM TEMPERATURE AND AT 550 F.

Specimen	Sulfur, per cent	Copper, per cent	Tin, per cent	Zinc, per cent	Lead, per cent	Yield Point, psi.	Tensile Strength, psi.	Elongation, per cent	Brinell Hardness Number
Room Temperature									
No. 11..................	0.117	87.88	6.27	3.39	1.99	18 700	41 300	41.1	61
No. 12..................	0.169	87.80	6.33	3.49	1.92	18 900	41 800	43.8	65
No. 13..................	0.210	88.14	6.36	3.13	1.87	18 900	40 900	39.2	65
No. 14..................	0.250	87.28	6.11	4.34	1.73	18 700	40 400	38.8	65
No. 15..................	0.336	87.70	6.16	3.66	1.85	18 300	40 500	41.5	70
550 F.									
No. 7..................	0.113	88.38	5.99	3.34	1.89	13 200	26 000	18.4	59
No. 10..................	0.150	88.38	6.19	3.14	1.85	13 500	28 600	20.4	59
No. 11..................	0.229	88.66	6.54	2.32	1.96	13 800	26 600	15.4	61
No. 26..................	0.260	87.36	6.11	3.90	2.08	13 700	28 500	19.4	67
No. 13..................	0.313	87.80	6.08	3.70	1.82	13 800	28 400	17.6	61

TABLE IV.—EFFECT OF ANTIMONY ON PROPERTIES AT ROOM TEMPERATURE AND AT 550 F.

Specimen	Antimony, per cent	Copper, per cent	Tin, per cent	Zinc, per cent	Lead, per cent	Yield Point, psi.	Tensile Strength, psi.	Elongation, per cent	Brinell Hardness Number
Room Temperature									
No. 21..................	0.08	88.00	6.45	3.21	1.97	18 600	43 000	52.8	63
No. 22..................	0.24	87.80	6.22	3.69	1.85	18 100	41 000	42.2	61
No. 23..................	0.36	87.42	6.18	3.76	1.99	19 300	43 500	58.9	67
No. 24..................	0.45	88.00	6.01	3.88	1.46	17 200	39 400	42.5	57
550 F.									
No. 25..................	0.10	88.34	6.17	3.26	1.84	13 300	28 800	18.4	57
No. 26..................	0.24	88.16	6.11	3.44	1.85	14 400	28 300	18.1	57
No. 27..................	0.37	87.78	6.06	3.77	2.23	13 500	27 100	14.6	63
No. 28..................	0.40	88.06	6.01	3.77	1.56	13 500	27 000	17.4	59

TABLE V.—EFFECT OF COMBINATION OF SULFUR AND ANTIMONY ON PHYSICAL PROPERTIES OF STEAM METAL AT ROOM TEMPERATURE AND AT 550 F.

Specimen	Sulfur, per cent	Antimony, per cent	Copper, per cent	Tin, per cent	Zinc, per cent	Lead, per cent	Yield Point, psi.	Tensile Strength, psi.	Elongation, per cent
ROOM TEMPERATURE									
No. 29	0.050	0.14	87.70	5.96	4.35	1.80	18 600	41 900	48.5
No. 30	0.050	0.20	88.10	5.84	3.80	1.71	18 000	41 300	47.9
No. 31	0.097	0.13	87.68	6.17	3.86	1.77	17 500	41 400	52.4
No. 32	0.093	0.17	87.84	6.08	3.69	1.84	17 900	42 000	47.2
No. 33	0.098	0.19	87.74	6.19	3.77	1.70	18 100	42 300	45.8
No. 34	0.095	0.43	87.64	5.93	4.26	1.82	17 900	40 100	35.7
No. 35	0.099	0.56	87.18	5.94	3.84	1.98	18 600	42 100	40.2
No. 36	0.130	0.17	87.28	6.00	4.40	1.82	17 500	39 500	36.3
No. 37	0.165	0.20	87.54	6.07	4.12	1.70	19 300	41 200	36.8
No. 38	0.173	0.28	87.54	5.89	4.25	1.66	19 200	41 300	37.9
No. 39	0.153	0.41	87.38	5.87	4.10	1.76	18 500	42 200	40.9
No. 40	0.162	0.48	86.80	6.01	4.64	1.61	18 600	40 300	34.7
No. 41	0.133	0.53	87.46	5.90	4.19	1.49	18 500	41 600	40.0
No. 42	0.205	0.32	87.42	5.86	4.26	1.73	18 600	40 000	33.4
No. 43	0.201	0.34	87.20	5.99	4.17	1.80	18 400	39 600	33.8
No. 44	0.216	0.54	87.22	6.00	4.02	1.70	18 400	38 900	30.9
No. 45	0.270	0.36	86.40	6.17	4.36	2.06	19 300	38 300	26.8
550 F.									
No. 46	0.050	0.10	87.72	5.84	4.00	1.99	13 800	28 100	19.8
No. 47	0.052	0.13	88.14	6.03	3.57	1.78	13 800	24 400	15.6
No. 48	0.073	0.17	87.32	5.93	4.56	1.75	14 000	30 100	24.9
No. 49	0.099	0.13	88.00	6.12	3.33	2.03	14 000	28 500	17.8
No. 50	0.098	0.19	87.32	5.95	4.56	1.59	14 000	28 600	18.7
No. 51	0.093	0.26	87.20	6.06	4.45	1.65	14 000	28 200	17.5
No. 52	0.100	0.30	87.12	5.86	4.75	1.57	13 900	25 700	14.5
No. 53	0.090	0.41	86.88	5.97	4.70	1.73	14 300	26 200	12.8
No. 54	0.125	0.09	87.92	6.15	3.69	1.82	14 000	27 300	15.6
No. 55	0.149	0.40	87.04	5.87	4.54	1.70	14 200	25 600	12.9
No. 56	0.160	0.18	87.54	5.79	4.28	1.75	13 800	27 300	16.9
No. 57	0.132	0.32	86.96	6.26	4.37	1.66	14 400	25 400	11.0
No. 58	0.175	0.20	87.48	6.07	4.16	1.71	14 500	26 700	13.9
No. 59	0.187	0.51	87.12	6.00	4.12	1.76	14 300	25 400	12.9
No. 60	0.225	0.31	87.44	6.04	3.83	1.85	14 200	27 300	16.1
No. 61	0.260	0.39	87.40	5.93	4.17	1.65	14 400	25 900	11.8
No. 62	0.200	0.53	87.10	5.86	4.45	1.56	14 300	24 900	10.9

TEMPERATURES

Investigation of melting and pouring temperatures showed that 2400 F. top furnace temperature and 2150 F. pouring temperature yielded the best results and these temperatures were used throughout. Temperatures were measured either with a platinum-platinrhodium thermocouple in a silica protection tube, or with an open-end chromel-alumel couple. Consistent readings could be made with either type, the open-end couple causing no detectable contamination of the melt. Measurements were made with a potentiometer.

Tests were made on a hydraulic testing machine. The elevated temperature tests were made in accordance with the A.S.T.M. Tentative Method E 21.[11] A Templin type recording extensometer with a magnification of 500:1 was used. Yield strength was taken at 0.2 per cent offset under stress.

In Table II are given results on the impurity-free alloy together with analyses. (This method gives results a trifle lower than yield strength at 0.5 per cent elongation.)

EFFECT OF SULFUR

Sulfur was added in the powdered form at the beginning of the heat with recovery nearly 100 per cent. Analyses were made for sulfur volumetrically with a "Sulfur Determinator" which were also checked very closely with the barium sulfate method against standard samples.

Sulfur was added up to 0.3 per cent or approximately six times that allowed in the ingot specification. In Table III the analyses and physical properties are given for the sulfur bearing alloys at room temperatures and at 550 F.

It is seen from these results that sulfur *per se* up to 0.3 per cent has no adverse effect on the physical properties of steam bronze either at room temperature or at maximum rated service temperature of 550 F.

EFFECT OF ANTIMONY

Antimony was added to the base mixture as pure metal in amounts up to 0.5 per cent. Recovery was good. The data on effect of antimony at room temperature and at 550 F. are given in Table IV.

From these data it may be seen that antimony up to twice the amount allowed in the ingot (assumed to be greater than would be found in the castings) is not detrimental *per se* either at room temperature or at 550 F.

TABLE VI.—REARRANGEMENT OF TABLE V.

Specimen	Elongation, per cent	Tensile Strength, psi.	Sulfur, per cent	Antimony, per cent
ROOM TEMPERATURE				
No. 7	50.8	40 900	None	None
No. 31	52.4	41 400	0.10	0.15
No. 29	48.5	41 900	0.05	0.15
No. 30	47.9	41 300	0.05	0.20
No. 32	47.2	42 000	0.10	0.15
No. 33	45.8	42 300	0.10	0.20
No. 39	40.9	42 200	0.15	0.45
No. 35	40.2	42 100	0.10	0.55
No. 41	40.0	41 600	0.15	0.55
No. 38	37.9	41 300	0.20	0.30
No. 37	36.8	41 200	0.15	0.20
No. 36	36.3	39 000	0.15	0.15
No. 34	35.7	40 100	0.10	0.45
No. 40	34.7	40 300	0.15	0.50
No. 43	33.8	39 600	0.20	0.35
No. 42	33.4	40 000	0.20	0.30
No. 44	30.9	38 900	0.20	0.55
No. 45	26.8	38 300	0.25	0.35
550 F.				
No. 10	22.4	30 600	None	None
No. 48	24.9	30 100	0.05	0.15
No. 46	19.8	28 100	0.05	0.10
No. 50	18.7	28 600	0.10	0.20
No. 49	17.8	28 500	0.10	0.15
No. 51	17.5	28 200	0.10	0.25
No. 56	16.9	27 300	0.15	0.20
No. 60	16.1	27 300	0.20	0.30
No. 54	15.6	27 300	0.15	0.10
No. 47	15.6	24 400	0.05	0.15
No. 52	14.5	25 700	0.10	0.30
No. 58	13.9	26 700	0.20	0.20
No. 55	12.9	25 600	0.15	0.40
No. 59	12.9	25 400	0.20	0.50
No. 53	12.8	26 200	0.10	0.50
No. 61	11.8	25 900	0.25	0.40
No. 57	11.0	25 400	0.15	0.50
No. 62	10.9	24 900	0.20	0.50

Effect of Combined Sulfur and Antimony

Combinations of sulfur and antimony were investigated; the alloys and their physical properties at room temperature and at 550 F. are listed in Table V.

In Table VI the data of Table V are arranged in order of decreasing elongation together with nominal sulfur and antimony contents.

From Table VI it will be seen that at room temperature all specimens pass the minimum physical requirements of specification B 61.[3] Nevertheless, with good foundry practice the specimens should be expected to show 40 per cent elongation and/or 40,000 psi. tensile strength. In other words if the foundry practice were such as to give a bar just passing the minimum specification, bars that are deficient in Table V could be expected to be below this minimum.

Actually, the differences in order of results shown in Tables V and VI are not great; that is, with increase in sulfur and antimony additions there is a slight but general degradation of properties. Certain specimens appear to be misplaced in the order of Table VI. Specimen No. 41 would be expected to be deficient in properties, considering the general trend. Actually, the properties are good.

In general, examination of the data shows that the apparent limits on sulfur and antimony, insofar as physical properties are concerned, are 0.15 per cent sulfur and 0.30 per cent antimony; that is, sulfur and antimony in these amounts can be tolerated without materially diminishing the physical properties. No specimen was good with 0.20 per cent sulfur if the antimony was increased beyond 0.30 per cent.

There are no specifications for properties at elevated temperatures of the alloy covered in Specifications B 61.[3] However, the A.S.M.E. Boiler Construction Code[14] permits a design stress in this alloy (as used at 550 F.) of about one half the design stress for room temperature application. To apply this rule to A.S.T.M. Specifications B 61, minimum requirements of 8000 psi. yield strength and 17,000 psi. tensile strength, would be needed for elevated temperature service. Again it will be seen that all specimens would meet this minimum requirement with the exception of specimen No. 62 which would not quite pass the elongation.

Elevated temperatures affect the elongation more than the tensile or yield strengths. Specimen No. 10 showing a 56 per cent loss in elongation over specimen No. 7 but only a 25 per cent loss in tensile strength as a result of temperature alone, both specimens being impurity free. Hence, our criterion for good specimens at room temperature tests, namely, 40,000 psi. tensile strength or 40 per cent elongation, or both, could be readily halved for elevated temperature requirements so far as tensile strength is concerned but not as regards elongation. Specimens No. 47, for example, is within the present limits for impurities but low on elongation using a 20 per cent minimum figure; specimens with less impurities are scarcely better.

If the maximum safe limit for impurities found in the room temperature tests is applied, an elongation in excess of 15 per cent at 550 F. should be attained with good foundry practice. This might be thought a reasonably safe minimum, since all specimens would well exceed the 20,000 psi. minimum tensile strength requirement.

Conclusion

It would appear that present implied impurity limits for castings are unduly restrictive as regards the impurities sulfur and antimony. In this report only results obtained on test bars of the alloy have been given. It is recognized that increasing the impurity content above the present ingot limits implies a possibility of foundry difficulties. However, so far as application is concerned only the physical properties of the materials should be a part of the specification. As the impurities sulfur and antimony definitely are harmful above certain limits, it is felt that such limits should be fixed in the specification.

So far as the ingot metal specification B 30[5] is concerned, the impurity limits apparently were fixed according to the user's desires and the availability of proper scrap. It is a further obligation of the ingot manufacturer to provide ingot which assures freedom from whatever foundry difficulties would be entailed by the carrying of excessive amounts of unwanted impurities, dross, etc. Since no tests are reported in this paper on foundry qualities of the high-purity bronzes, it may be well to consider other work regarding this question. Gardner and Saeger[8] studied the foundry problems connected with antimony additions to ounce metal (A.S.T.M. Specifications B 62[9]) rather exhaustively, and concluded that antimony up to 0.25 per cent (the limit in their work) had no detectable effect on this alloy other than an apparent increase in fluidity. In somewhat less detail they reported similarly in an earlier paper[7] on the effects of sulfur and iron. Again, except for slightly improved running qualities no detectable effects of sulfur on foundry qualities could be detected up to 0.10 per cent, their limit for this element.

The handling of the two alloys, covered in Specifications B 61 and B 62, are rather similar in most foundries, similar gating methods often being used. Thus, if 0.10 per cent sulfur and 0.25 per cent antimony are not detrimental to the handling of the alloy of B 62, it is implied that the same elements are not likely to cause increased difficulties with the alloy of B 61.

In this paper it has been shown that sulfur and antimony contents somewhat higher than those permitted or implied in castings specifications are not detrimental to physical properties either at room temperature or at the maximum permissible service temperature. It appears that maximum impurity on these two elements might be revised upward. This would permit greater latitude in the selection of materials, both composition ingot and "virgin" metals during the war.

Summary

Effects of the elements sulfur and antimony on the physical properties of steam bronze (A.S.T.M. Specifications B 61) have been studied both at room temperature and at the maximum permitted service temperature of 550 F. The impurity limits studied in the present investigation extend to 0.25 per cent sulfur and 0.50 per cent antimony, both alone and in combination.

All specimens tested at room temperature well exceeded A.S.T.M. specification requirements for this alloy.

[14] ASME-BCC, Section VIII, Unfired Pressure Vessels, Table 11-3.

All specimens tested at 550 F. would prove satisfactory should the criterion of excellence be based on the A.S.M.E. Boiler Construction Code limit on design stress for 550 F. service, which is one half that of the room temperature design stress, with the exception of one specimen containing the maximum amount of impurities studied which was somewhat deficient in elongation.

A slight general degradation of physical properties is noted with increasing impurity content. It is suggested that A.S.T.M. Specifications B 61 (also Governmental and other specifications) be revised to include limits on these impurities. Maximum limits of 0.10 per cent sulfur and 0.25 per cent antimony are suggested at present.

Although no work has been carried out with respect to foundry qualities in bronze with these impurities, the work of Gardner and Saeger on a similar alloy (A.S.T.M. Specifications B 62) suggests that no difficulties would be encountered by the presence of up to 0.10 per cent sulfur and/or 0.25 per cent antimony.

Autogenous Healing in Mortars Containing Lime

By F. O. Anderegg[1]

IT HAS BEEN SHOWN by Abrams[2] and by Gilkey[3] that portland-cement mortar or concrete, which had been tested to failure, will recover a large part of its original strength when subjected to suitable conditions of storage. This phenomenon of autogenous or self-healing has been explained by Abrams as a probable deposition of soluble material in and across the cracks caused by the failure. Since lime is the most abundant soluble compound present in portland cement, it appears probable that lime is one of the active agents in autogenous healing. The "glass seams" formed by deposition of calcite in cracks in Indiana (Salem) limestone may be considered as an example of autogenous healing in nature. This note presents data on autogenous healing in mortars high in lime.

Two series of cubes were made up in the proportion of one bag of portland cement, two bags of hydrated lime (or, the same weight of lime solids in the putty), and 720 lb. dry sand (approximately 1 : 2 : 9 by volume). The portland cement was a blend of four standard brands. The sand was a local sand previously described.[4] The first series of cubes contained a dolomitic hydrated lime having 16 per cent of its MgO content converted to $Mg(OH)_2$. The second series contained a high-yield, high-calcium lime putty. The mortars were adjusted to a flow of 110 per cent 1 hr. after starting the mixing, which had continued for 10 min. The cubes contained water in proportion to the solids of 19.8 and 22.6 per cent, respectively.

All cubes were removed from the molds at 24 hr. Three cubes in each series were then tested in compression in the usual manner, completely crushing the specimens. Five cubes were stored without any loading, while the remainder were placed in the testing machine at 24 hr. and loaded but the application of load was stopped at the first indication of failure (formation of shear cracks and dropping back of the load-indicating needle). As a result of this loading the cubes were shortened 8.4 per cent on the average. They, however, remained whole and could be handled. Seven of these cubes are shown in Fig. 1. All of these cubes were then stored in unchanged water for six months, and were tested at that age wet. All the results obtained are given in Table I.

TABLE I.—AUTOGENOUS HEALING AFTER PRELIMINARY LOADING OF 1:2:9 MORTAR CUBES.

A = Dolomitic hydrated lime series.
B = High-calcium lime putty series.

	Initial Loading at 24 hr., psi.		Compressive Strength After 6 months' Healing, psi.		Compressive Strength of Controls at 6 months, psi.	
	A	*B*	*A*	*B*	*A*	*B*
No. of cubes.....	11	12	11	12	5	5
Maximum.......	162	95	800, 776	395, 403	650	368
			776, 750	382, 385	688	378
Minimum........	148	93	778, 700	373, 393	638	378
			762, 750	370, 388	663	383
			776, 776	345, 383	663	368
			780	375, 390		
Average.........	155	94	766	380	660	375
Shape correction applied			719	357		

The healed specimens had been flattened slightly during the initial loading. To secure a fair comparison with the control cubical specimens, an empirical correction factor was applied, as previously described.[4] From these data the following conclusions appear to be warranted:

1. High-lime mortars are autogenously healed in the presence of water.

2. The degree of healing under the conditions of tests is slightly greater for mortar made from hydrated dolomitic lime than for mortar made from high-yield, high-calcium quicklime.

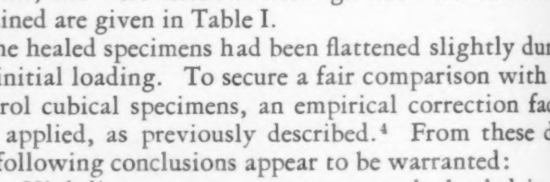


Fig. 1.—Cubes Which Have Been Loaded to Nearly Complete Failure, Without Complete Crushing. Shear cracks have started to form.

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[1] Consulting Specialist on Building Materials, Newark, Ohio.

[2] D. A. Abrams, "Test of a 40-foot Reinforced Concrete Highway Bridge," *Proceedings*, Am. Soc. Testing Mats., Vol. XIII, p. 884 (1913).

[3] Herbert J. Gilkey, "The Tensile Autogenous Healing of Portland Cement Mixtures," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, p. 593 (1929).

[4] F. O. Anderegg, "Some Properties of Mortars in Masonry," *Proceedings*, Am. Soc. Testing Mats., Vol. 41, p. 1130 (1941).

Machines for Testing Reciprocating Packings[1]

By F. C. Thorn[2]

For a long time the author has been of the opinion that the art of testing packings was not altogether satisfactory. The accepted criteria for quality—rubber content, tensile strength, ply adhesion, and their like—have been, at the worst, wholly false and misleading, and at the best, not proven. The situation is especially unsatisfactory at a time when, owing to the need for the use of substitutes, the old criteria can no longer be met, and yet quality adequate to the service must be maintained somehow or other if the industrial machine is not to bog down under a burden of packing failures.

In times of flux, it is always best to get back to first principles, and first principles in this case consist in testing packings under conditions as nearly approaching service as possible. A discussion of packing test equipment would, therefore, appear to be timely. This is especially true in the field of reciprocating packings which have acquired a new importance as a result of the mushroomlike growth of pneumatic and hydraulic equipment, and for which little information along the lines of test equipment has been made public.

A reciprocating test machine, like any other test machine, should reproduce service closely, but not too closely. The fact that it is a test machine and that it is expected to give reproducible results imposes special requirements. In general, a test machine should copy service in the following particulars:

1. It should test packings of the same kind and size as are employed in service.
2. It should employ the same fluid, at the same temperature and pressure.
3. It should move the packing in the same direction relative to the metal surfaces, or the metal surfaces in the same direction relative to the packing.

The last requirement warrants a digression. Reciprocating fluid-handling machines are energy-converters, which is to say that they convert the volume energy of the fluid into mechanical motion, or *vice versa*. If the former, they are motors, in which class are included steam engines, air hoists and hydraulic cylinders. If the latter, they are pumps, used in the generic sense to include also gas compressors and fluid-braking devices, such as door checks. The packing requirements for a motor and for a pump are often quite unlike. Consider the single-acting piston (Fig. 1). If operated as a motor, the piston moves from left to right, and the packing retreats from the pressure. If operated as a pump, the piston moves from right to left, and the packing advances against the pressure, or, in colloquial language, "stubs its toe." This may impose a much more severe requirement on the packing, and should be taken into account in the design of a testing machine.

It should not be inferred that all pumps are more severe on their packings than all motors. Consider, for instance, the single-acting plunger (Fig. 2). If operated as a motor, the packing "stubs its toe"; if operated as a pump it does not. Perhaps it would be better for the packing if all motors were of the piston type, and all pumps of the plunger type, but this is not always possible. For one thing, many are dual-purpose machines; they function as a pump at times and as a motor at others. This is true generally of motors working against reversible forces such as gravity. A hydraulic jack, for instance, is a motor going up, and a pump coming down. This is true also of many airplane cylinders, such as the ones that raise the landing gear. For these, packings have to be capable of acting in both directions.

With more complicated setups, it takes some study to realize just what the effective pressures are, and in what directions they are acting. Consider the double-acting piston motor in Fig. 3 (*a*) which is shown as acting under 1000 psi. inlet pressure, and 800 psi. back pressure. Superficially it might be concluded that packing *A* is retreating from 1000 psi. pressure, and packing *B* is advancing against 800 psi. Actually, packing *A* is retreating from an effective pressure of 200 psi. and packing *B* is idle. However, tap the space between the packings with the seemingly innocent leakage detector shown in Fig. 3 (*b*) and the original supposition becomes correct. Also the life of the packings is shortened to a fraction of what it would have been under the first set of conditions. Leakage detectors should not be inserted into testing machines if they destroy the similarity between the testing machine and service.

The testing machine should differ from service in the following respects:

1. It should test only one kind of packing at a time. Packings for double-acting cylinders should be tested in two separate single-acting testing machines—one for piston packing, and one for rod packing.
2. It should test packings under the most favorable conditions; therefore, it should not incorporate features of the service which represent bad practice and which should be corrected. In general, and regardless of the con-

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[1] Presented at a meeting of Committee D-11 on Rubber Products, Cleveland, Ohio, March 4, 1942.

[2] Chief Chemist, The Garlock Packing Co., Palmyra, N. Y.

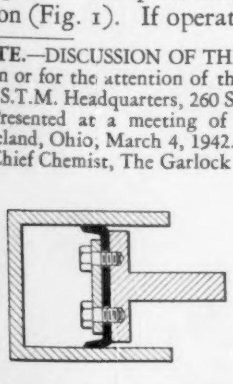


Fig. 1.—Single-Acting Piston.

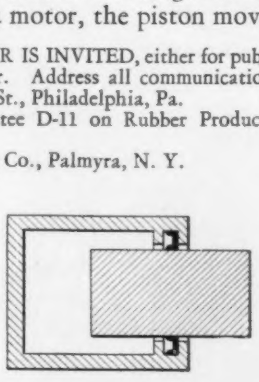
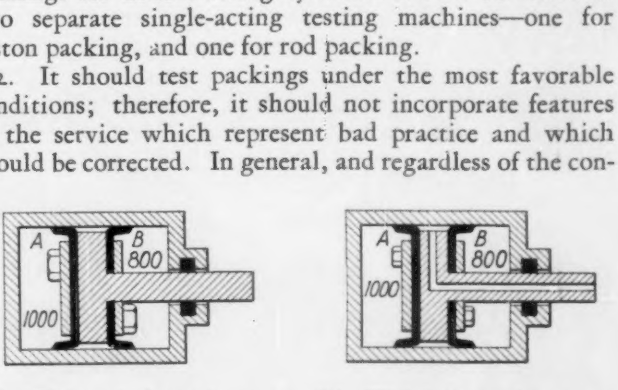


Fig. 2.—Single-Acting Plunger.



(*a*) Without leakage detector. (*b*) With leakage detector.
Fig. 3.—Double-Acting Piston Motor.

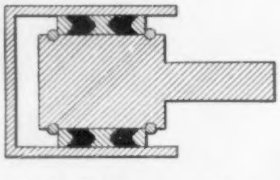


Fig. 4.—Faulty Design in a Piston Motor.

ditions of the service equipment it represents, the testing machine should be in good alignment, accurate, with smooth metal surfaces, and correct means for holding the packing in place.

As illustrating four common design errors which are unfair to packings and should not under ordinary circumstances be included in a testing machine, consider Fig. 4.

(*a*) Nonadjustable stuffing box—in general, packings cannot be made sufficiently accurate to develop just the right initial pressure when inserted into a space of predetermined depth; therefore, the snap ring should be replaced by a threaded nut.

(*b*) Floating piston—packings are not sufficiently elastic to withstand the constant battering to which they are subjected by a floating piston; therefore the piston should be integral with the piston hub.

(*c*) Male adapter making too close clearance to cylinder wall, causing pinching of lip of adjacent V-ring on retreating stroke.

(*d*) Male adapter deep which in conjunction with close clearance causes excessive pressure to develop on the advancing stroke, within the liquid trapped between the male adapter and cylinder wall.

By the same token, the packing should be given correct initial adjustment, proper lubrication, and the care and attention during test to which it is reasonably entitled. To know how long a packing will work under needlessly unfavorable conditions may be of academic but not of practical interest.

3. Since a testing machine is used over and over again, it should be designed with a view to ready disassembly. A packing in service may be crimped or spun into place—in a testing machine it should be held with screws. By the same token, the metal surfaces should be capable of ready replacement when they become worn or scored.

4. Facilities should be provided for the continuous collection and measurement of leakage.

5. Facilities should be provided for the continuous measurement of packing friction.

6. Motion should be uniform, even if motion in service is irregular or harmonic. This follows from the fact that friction can be measured only under conditions of uniform motion.

7. The test should, if possible, be accelerated, in the interests of getting an early answer. This can be accomplished by higher speed, if this does not introduce any new factor. More generally it can be accomplished by operating the testing machine continuously whereas service is intermittent. Useful information can, however, be gained from occasional shutdowns.

8. The testing machine should not be too costly to build and operate.

In the light of these requirements, it might be in order to consider some of the machines that have been employed to test reciprocating packings. These machines fall into four general categories: (*a*) simple motors, (*b*) simple pumps, (*c*) mixed types, and (*d*) balanced types.

(*a*) *Simple Motors.*—Our laboratory has not made use of any machines of this type, but they would correspond in general outline to Fig. 5. *A* and *B* are single-acting motors which are fed with the operating fluid alternately by a 4-way valve. *C* is an irreversible load which might be mechanical, as for instance, a rack-and-pinion operated brake drum; electrical, as, for instance, a dynamic brake; or fluid, as, for instance, a double-acting pump pumping to waste through a throttle valve.

Although this is the logical type of testing machine for packings employed on pure motor service, it suffers from at least one serious disadvantage: namely, there is no direct way of recording packing friction. Friction would be shown by a comparison between the product of pressure and area of the operating cylinders on one hand, and the actual mechanical thrust developed. The problem is to measure the latter. It can be done but necessitates either a frictionless hydraulic capsule in the line of the thrust, or some equivalent method, such as suspending part *C* from a platform scale. Either arrangement adds considerably to the complexity and cost.

(*b*) *Simple Pumps.*—Change brake *C* to an electric motor or steam cylinder, and substitute simple check valves for the 4-way valve, and the apparatus becomes a pair of single-acting pumps. The use of a pump to test pump packings is, of course, nothing new. A little motor-driven single-acting piston pump made over from a domestic water-supply system has done yeoman service in our laboratory as a testing machine for cups on oil service. As in the former case, the chief difficulty is its incapacity for giving a friction reading.

(*c*) *Mixed Types.*—The simplicity of operating against a reversible load has led to a large number of machines in which the packing is alternately a motor-packing and a pump-packing. If the packing is employed in this manner in service, there is nothing illogical about this. The hydraulic jack in Fig. 6, if fed oil or water by a 3-way valve, will raise and lower the weight at a uniform speed. Ram area times inlet pressure is greater than the weight by the amount of the packing friction; coming down, the product of ram area and outlet pressure is less than the weight by the same amount. By using two cylinders with a 4-way valve, the entire discharge from a gear pump can

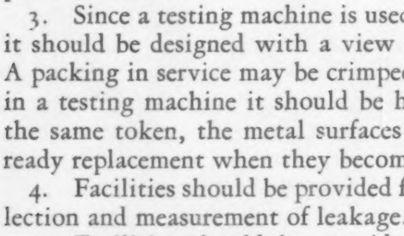


Fig. 5.—Simple Motor or Pump.

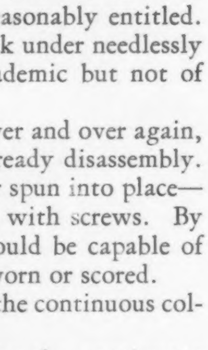


Fig. 6.—Hydraulic Jack.

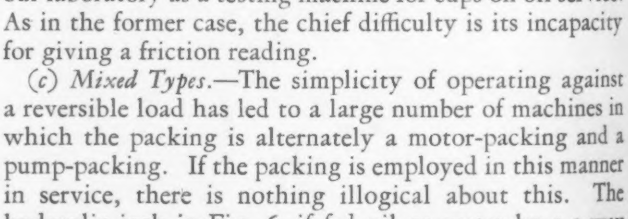


Fig. 7.—Opposed Cylinders.

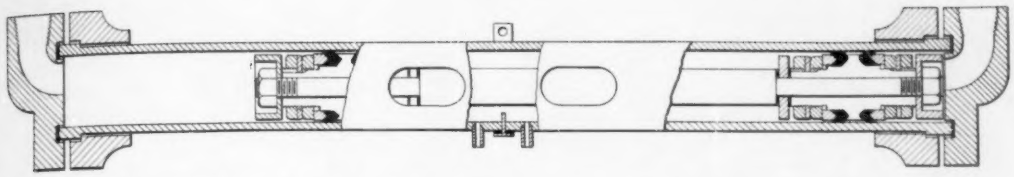


Fig. 8.—Improved Testing Machine for Piston Packing.

be usefully employed. A minor disadvantage of this method of loading is the cumbersome equipment required. A landing gear cylinder may be capable of lifting 6000 lb. This is equivalent to quite a sizable chunk of pig iron.

The most important advance in this type of test has been the use of one cylinder to oppose another of exactly the same type. To the best of my knowledge, this form of testing machine originated with Harold Adams of the Douglas Aircraft Co. In Fig. 7 a pair of double-acting cylinders are made to oppose one another through the medium of an intervening jack shaft running in bearings. Oil from a suitable gear pump is fed alternately to connections *A* and *B* through the medium of a 4-way valve whose reversals can be conveniently controlled by stops located on the jack shaft. While oil is admitted at one connection it escapes from the other through a throttle valve. By eliminating any accumulator from the system, the pistons are driven at a definite speed corresponding to the full pump discharge and the discharge pressure can be closely controlled by the setting of the throttle valve. The inlet pressure will exceed this value by a differential which, multiplied by the piston area, will exactly equal the combined friction of the four packings. While this is going on, connections *C* and *D* can be joined to a suitable atmospheric surge tank, or left open and facing downward to serve as leakage collectors. One problem in connection with this arrangement is that of getting all packings properly lined up with the jack shaft.

By employing the arrangement shown in Fig 4, the entire test can be conducted within a single cylinder. The 4-way valve connections are made to the opposite ends. The effect of the leakage port is to break up the piston into the equivalent of two separate pistons. A minor disadvantage of this arrangement is that it is not possible to tell from which packing the leak is coming. A more serious objection to both this and the preceding arrangement is the use of double-acting cylinders, with two sizes of packing under test simultaneously, and a friction reading which is a composite of both.

In an effort to get away from the disadvantages of the preceding methods and at the same time to simplify and cheapen the apparatus, our laboratory developed the machine shown in Fig. 8. It is seen to consist of a simple honed cylinder made from seamless tubing, readily replaceable, with standard flange fittings at the ends, drilled for connections. Within this cylinder float two pistons on a common piston rod. In the cross-section shown, the pistons are designed to accommodate aircraft "V" packings, but other pistons can be readily substituted. We have, for instance, constructed pistons to accommodate ordinary square-section rings, round-body rings, 45-deg. cones, and cup packings. This affords an excellent opportunity to compare these various types under identical conditions. The pistons are driven by oil admitted alternately to each end and simultaneously discharged from the other end through a throttle-valve, control of the oil flow being effected by a solenoid-operated 4-way valve, the switch for which is actuated by limit stops on the piston rod. Access to the rod is obtained by openings drilled in the cylinder as shown; leakage into this area is picked up by the two leakage collectors indicated.

Figure 9 shows this machine setup for operation. The rod operating the solenoid switches is in the foreground. The valves at the top of the cylinders serve to purge the

Fig. 9.—Improved Testing Machine for Piston Packing.

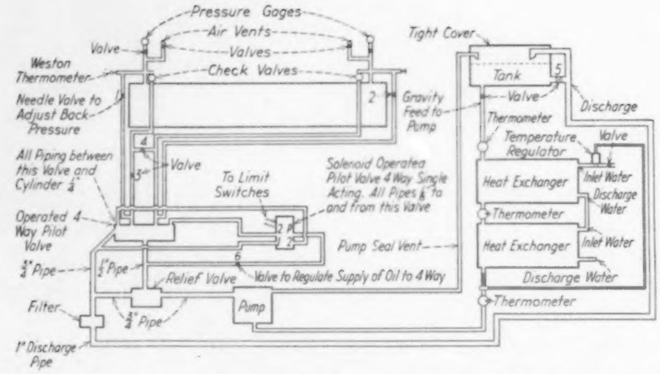


Fig. 10.—Piping Design for Machine Shown on Figs. 8 to 9.

system of any air at the beginning of the test. The pressure gages alternate continuously between inlet and discharge pressures, thereby providing a continuous and sensitive indication of the combined friction of the two similar packings. The thermometers are to insure that the thermostatically controlled oil-coolers are working properly. The piping diagram is shown in Fig. 10. Particular attention is called to the valves 3 and 4. By closing valves 1 and 3 and opening 4 the cylinder is left stationary for any desired period under full pressure at both ends. On closing valve 4 and opening 1, motion resumes. It is instructive to observe the friction necessary to break certain packings free after they have had an opportunity to grow fast to the cylinder wall. Attention is also called to the overhead tank. By stopping the pump, both cylinders are put under a low static head, permitting observation of leakage under these conditions. When we started testing we had the oil tank on the floor and the oil-filter on the pump inlet, and we wondered where all the air kept coming from. Of course it came through the pump shaft seal because of the vacuum at that point. Elevating the tank and putting the filter on the discharge eliminated that. Attention is also called to the throttle valve on the line leading to the pilot valve. This controls the rate of reversal and eliminates disastrous oil-hammer effects. By adjustment of the thermostatic control, the oil may be allowed to warm up to any desired degree; it seems reasonable to suppose that, by the use of a refrigerating compressor and suitable exchange apparatus, a switch to refrigerated oil could easily be effected.

This machine, of course, tests only piston packing. A similar machine for testing rod packing is shown in Fig.

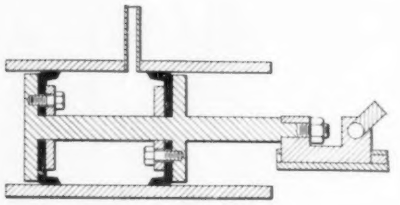


Fig. 12.—Balanced Testing Machine for Piston Packings.

11. The piping and method of operation are essentially the same as before. Various sizes and types of rod packings can be tested by building suitable stuffing boxes. The inboard bearings behind the packings are slotted to prevent them from developing a pumping action. With either of these machines it is possible to complete 100,000 cycles in less than a week. This represents a good many years in the life of aircraft packings, although it does not constitute much of an acceleration in the case of packings for machine-tool service.

Larger models of both machines have been built to test pneumatic packings in the form of either cups or U-packings up to 4 in. in diameter. The motive power is compressed air from the factory lines. In the case of the rod packing machine, it is not possible to collect the escaping air; an idea of the leakage can, however, be obtained by valving off one end, admitting air to the other and observing the drift. In the case of the piston machine, the central area is not open to the atmosphere but is tapped for a connection to an air meter, which gives a continuous leakage reading. This necessitates a relocation of the solenoid limit stops, which are located in the cylinder ends. This machine has lent itself admirably to a study of lubricating systems for air-cylinders—a factor which has a profound effect on packing service. There appears to be no reason why the same or similar machines should not be used to explore the field of steam- and water packings.

(d) Balanced Types.—One trouble with all the machines heretofore described is that they waste power. With light equipment, this is not so important, although the operation of the aircraft piston tester requires 2 hp., all of which reappears as heat in the oil. With heavy equipment, power becomes a serious factor. For instance, one would hesitate to install a 75-hp. motor just to find how packings function on an oil-well pump. For this purpose, a balanced tester is most useful.

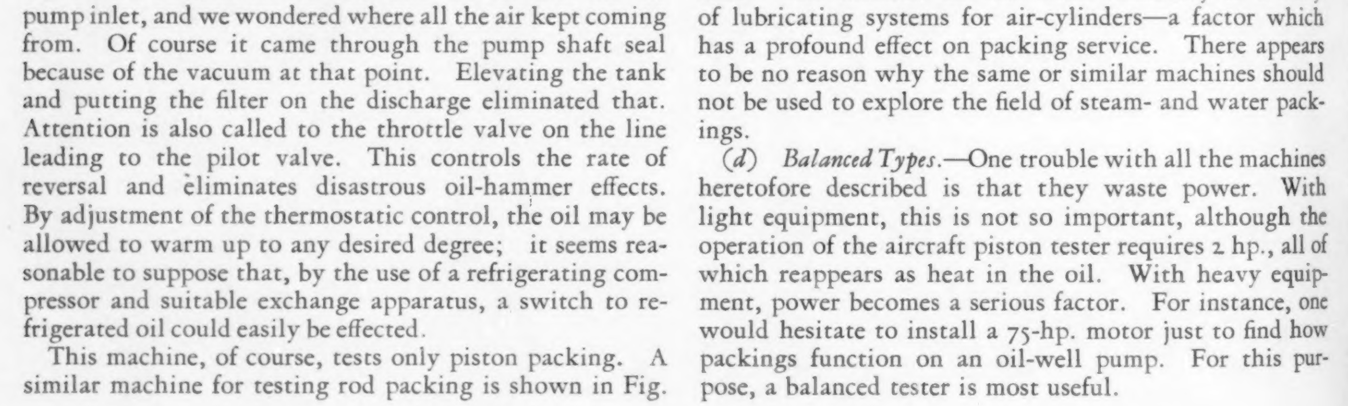


Fig. 11.—Improved Testing Machines for Rod Packings.

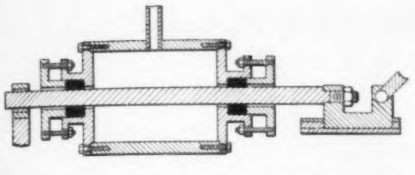


Fig. 13. Balanced Testing Machine for Rod Packings.

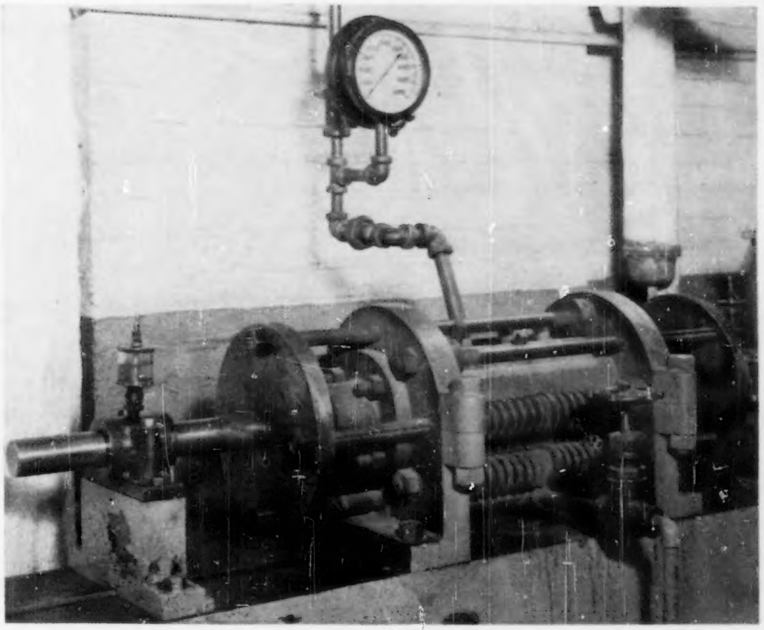


Fig. 14.—Balance Testing Machine fot Rod Packings.

Figure 12 shows somewhat diagrammatically a machine that was actually employed for testing oil-well packings. The piston is indicated in this illustration as a simple one with a simple cup, but the principle is the same. Into the space between the pistons the fluid (in this case kerosine at several thousand pounds pressure) is injected. Drive is by a motor and cross-head, which need only be strong enough to overcome friction since the pressure forces balance each other out. Cooling is by an external jacket, not shown. The packings are required to advance against the pressure on one stroke, which is not unfair in this instance, because it is what they do in service. Disadvantages are, of course, the absence of any way of determining friction, and the use of a harmonic rather than a uniform motion. Substituting a light fluid drive for the cross-head would remedy the latter, and might remedy the former if proper allowance could be made for the friction of the packing in the fluid motor.

A similar machine for testing rod packings is shown in Figs. 13 and 14. Although lacking the refinements of the self-propelled aircraft type of machine, it is running 24 hr. a day and giving useful information on the endurance of braided and Chevron packings for high-pressure water service, as well as packings for high-temperature steam rods.

150 at Philadelphia Meeting

An excellent audience of some 150 A.S.T.M. members, guests, and others in the Philadelphia area heard two very worth-while informal talks on the subjects of textiles and rubber, followed by a sound color movie entitled "Unfinished Rainbows," which told the story of aluminum, and at the close of the session enjoyed beer, doughnuts, and pretzels. Each phase of this meeting held at the Engineers' Club on April 30 was well received.

Prof. R. S. Cox, Assistant Dean of the Philadelphia Textile School, gave an interesting discussion on textiles and the effect of the present war situation on various branches of the industry. His opening remarks pertained to the Philadelphia situation, where he stressed the facilities for doing specialty work and some of the problems of converting these mills to produce fabrics needed in such huge quantities for the Government. In discussing the outfitting of our marines, sailors, and soldiers, he emphasized the tremendous quantities of wool needed and the effects of this on civilian supply. In the course of his discussion, Prof. Cox decried the use of the word "substitute" in the sense of implying an inferior product, pointing out that in many cases the materials which are developed for use are quite satisfactory and sometimes superior to the original. In the development of rayon, for example, cotton, wool, and silk were not replaced to any great extent, but the material developed its own market and is now, of course, in tremendous demand. He gave some interesting information about parachutes, some general idea of the quality and amount of material necessary to fabricate the chute, and stressed the specification requirements for this. This is a field where nylon is playing such an important role. In conclusion he stressed the contribution of the textile industry to our Victory Program stating his belief that a very honest effort is being made by the entire industry, to do all that it possibly can. A very high percentage of mills are working full time on Government orders.

Interesting phases of the development of crude rubber, how the industry was established, problems of collecting latex, and such information formed the introduction of Mr. O. M. Hayden's discussion. He is Assistant Manager, Rubber Chemicals Division, E. I. du Pont de Nemours & Co., and Chairman of A.S.T.M. Committee D-11 on Rubber Products. Mr. Hayden covered the supply problem with a chart and stressed the relatively low quantities of crude which can be obtained from such sources as Mexican guayule, Brazil, and related locations, each of which, however, will add something to what we will have to use. His talk was made more interesting by passing through the audience samples of various types of rubber—guayule, the type made by Indians in Brazil, and other products including camel back (we understand all samples were safely returned to Mr. Hayden!). He referred to some of the schemes which have been offered to alleviate the present situation and mentioned a jolting ride he had had in a car with wooden tires. In conclusion, Mr. Hayden gave some figures released through Government sources showing the tremendous shortage there would be in 1943

and 1944 unless civilian consumption were completely curtailed.

Alexander Foster, Jr., Vice-President, Warner Co., was Technical Chairman of the meeting. Refreshments were served through the courtesy of L. H. Winkler, Bethlehem Steel Co., Inc., and F. G. Tatnall, Baldwin Southwark Division, The Baldwin Locomotive Works, and Chairman of the Philadelphia District Committee. Other local members of the District Committee who assisted in various phases of the meeting included Tinius Olsen, 2d, J. F. Vogdes, Jr., and A. O. Schaefer.

Partial List of Emergency Alternate Federal Specifications

A LARGE NUMBER of Emergency Alternate Federal Specifications have been received at A.S.T.M. Headquarters and in line with the policy of announcing these, there are given below the specification number and brief description of the particular item. *However*, because the number received in the past few weeks is very large, an attempt has been made to list only those which would be of particular interest to a reasonable cross-section of A.S.T.M. members.

Partial List of Emergency Alternate Federal Specifications

Specification Number	Description
E-HH-F-201	Felt; Coal-Tar-Saturated, (for) Roofing and Waterproofing
E-J-C-103	Cable and Wire; Rubber-Insulated, Building-Type (0 to 5,000-Volt Service) (supersedes E-J-C-103, dated December 24, 1941)
E-LLL-B-631a	Boxes; Fiber, Corrugated (supersedes E-LLL-B-631a, dated January 24, 1942)
E-QQ-B-691a	Bronze Castings (supersedes E-QQ-B-691a, dated September 16, 1941)
E-RR-F-191	Fencing; Chain-Link or Welded (supersedes E-RR-F-191, dated June 2, 1941)
E-RR-T-51a	Tableware; Silver-Plated (supersedes E-RR-T-51a, dated November 8, 1942)
E-TT-S-176a	Sealer, Floor; Varnish-Type (for Wood and Cork)
E-W-B-616	Boxes and Outlet-Fittings, Floor; (for) Rigid-Steel-Conduit and Electric-Metallic-Tubing Steel) (supersedes E-W-B-616, dated February 27, 1942)
E-W-F-406	Fittings; Cable and Conduit (supersedes E-W-F-406, dated February 27, 1942)
E-W-O-806	Outlet-Bodies; Iron (Cast or Malleable), Cadmium- or Zinc Coated, with Covers and Accessories (for Shore Use) (supersedes E-W-O-806, dated February 27, 1942)
E-WW-U-516	Unions; Brass or Bronze, 250-Pound (supersedes E-WW-U-516, dated November 29, 1941)
E-WW-U-531	Unions; Malleable-Iron or Steel, 250-Pound (supersedes E-WW-U-531, dated November 29, 1941)
E-WW-U-536	Unions; Malleable-Iron or Steel, 300-Pound (supersedes E-WW-U-536, dated November 29, 1941)
E-WW-V-51	Valves, Brass or Bronze; Angle and Globe, 150-Pound S.W.P. (for Land Use)
E-WW-V-76b	Valves, Gate; 125 Pound, Threaded and Flanged (for Land Use)
E-ZZ-H-421a	Hose Chemical
E-ZZ-T-301	Tile; Floor, Rubber
E-ZZ-T-381d	Tires, Pneumatic; Automobile and Motorcycle
E-ZZ-T-831b	Tubing; Rubber

Navy "E" Awards to Many A.S.T.M. Members

IT HAS BEEN indicated that a great many individuals and organizations represented in the A.S.T.M. membership are rendering important service in many different capacities in connection with the present emergency. Some indication of this situation is given by the large number of companies in A.S.T.M. who have been awarded the coveted Navy Department "E" Award for outstanding service. A list of the companies who are affiliated with A.S.T.M. and who have received the Award follows. For the most part the organizations are so-called company or sustaining members although in a few cases the company is represented through memberships held by individuals. This list covers awards made from August, 1941, through April, 1942.

Aluminum Co. of America, New Kensington, Pa.
American Car & Foundry Co., Wilmington, Del.
American Locomotive Co., Schenectady, N. Y.
American Steel Foundries, Inc., Chicago, Ill.; Granite City, Ill., plant; Indiana Harbor, Ind., plant.
Bath Iron Works Corp., Bath, Maine
Bausch & Lomb Optical Co., Rochester, N. Y.
Bell Aircraft Corp., Buffalo, N. Y.
Bethlehem Steel Co., Bethlehem, Pa.
Bridgeport Brass Co., Bridgeport, Conn.
Brown & Sharpe Manufacturing Co., Providence, R. I.
Edward G. Budd Manufacturing Co., Philadelphia, Pa.
Cameron Iron Works, Inc., Houston, Tex.
Carnegie-Illinois Steel Co., Homestead, Pa.
Carrier Corp., The, Syracuse, N. Y.
Chase Brass & Copper Co., Inc., Waterbury, Conn.
Cincinnati Milling Machine Co., Cincinnati, Ohio
Crucible Steel Co. of America, Harrison, N. J.; Midland Plant, Midland, Pa.
Doehler Die Casting Co., Pottstown, Pa.
Dravo Corp., Neville Is. Station, Pittsburgh, Pa.
E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.
Electric Boat Co., Groton, Conn.
Electric Storage Battery Co., Philadelphia, Pa.
Erie Forge Co., Erie, Pa.
Fisher Body Division, General Motors Corp., Detroit, Mich.
Ford Instrument Co., Long Island City, N. Y.
The Fulton Sylphon Co., Knoxville, Tenn.
Heppenstall Co., Pittsburgh, Pa.
International Nickel Co., Huntington, W. Va.
Kropp Forge Co., Chicago, Ill.
Lukens Steel Co., Coatsville, Pa.
P. R. Mallory & Co., Inc., Indianapolis, Ind.
The McKay Co., Pittsburgh, Pa.
Mesta Machine Co., Pittsburgh, Pa.
Midvale Co., Nicetown, Philadelphia, Pa.
Miehle Printing Press and Manufacturing Co., Chicago, Ill.
Monsanto Chemical Co., St. Louis, Mo.; Anniston, Ala., plant; Monsanto, Tenn.
Mueller Brass Co., Port Huron, Mich.
National Cash Register Co., Dayton, Ohio
National Forge and Ordnance Co., Irvine, Pa.
New York Air Brake Co., Watertown, N. Y.
New York Shipbuilding Corp., Camden, N. J.
Newport News Shipbuilding and Dry Dock Co., Newport News, Va.
Norfolk Navy Yard, Norfolk, Va.
Norton Co., The, Worcester, Mass.
Permold Works, The, Cleveland, Ohio
Pratt & Whitney Aircraft Division of the United Aircraft Corp., East Hartford, Conn.
R.C.A. Manufacturing Co., Camden, N. J.
John A. Roebling's Sons Co., Trenton, N. J.
SKF Ball Bearing Co., Philadelphia, Pa.
Standard Steel Works, Division of the Baldwin Locomotive Works, Burnham, Pa.
Wyckoff Drawn Steel Co., Pittsburgh, Pa.
Naval Shore Stations
Naval Gun Factory, Washington, D. C.
Naval Torpedo Station, Newport, R. I.

High Sensitivity in Radium Radiography of Castings[1]

By L. W. Ball[2]

The purpose of this paper is to show that with suitable exploitation of the emulsion characteristics of Noscreen film, radium radiography provides a highly satisfactory method for the examination of steel[3] castings from $^1/_4$ to 6 in. thick.

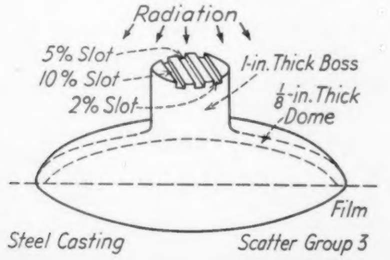
As with light-alloy aircraft castings, it is essential to separate steel castings into three groups before discussing suitable radiographic procedure. Segregation of castings into these three groups must be based on the degree to which detrimental secondary radiation will be present in the radiographic image of each casting.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[1] The substance of this article formed the second part of an address entitled "Two Recent Advances in the Technique of Industrial Radiography" delivered to Committee E-7 on Radiography at the June, 1941, meeting. The first part of this address, entitled "A Study of Secondary Radiation in Relation to the Radiography of Aircraft Castings," appears in the March, 1942, ASTM Bulletin, p. 27.

[2] Physicist, National Research Laboratory, Ottawa, Ont., Canada.

[3] Castings of brass, bronze, zinc, etc., may be regarded as similar to steel.



In the first group of "well-blocked" castings, neither back scatter nor forward scatter presents serious difficulty. Continuous plate sections or disk-shaped objects that can be surrounded by copper shot or lead masks so as to resemble continuous plates are of this type. Large welded cylinders also present the same conditions. In general, 200-kv. radiography is satisfactory for examination of this group of castings.

The second group of "moderately blocked" castings are of such shapes that part of the direct beam passes around the casting and is back scattered and rescattered, but forward scatter is not excessive. In general, 600-kv. radiography with lead intensifying screens is satisfactory for this group. A thick back lead screen is essential to reduce greatly back scatter from behind the film.

In the third group of "badly blocked" castings, the shapes are such that in addition to the back scatter problem, forward transmitted scatter from thin sections of the casting undercuts into the image of thick sections remote from the film, and thereby prevents a sensitive examination of the thick sections. In general, radium radiography is the most reliable method of examining this group of castings. If X-rays are used, they must be heavily filtered to approximate a monochromatic beam of hard rays. This is necessary because the "soft" X-rays that contribute nothing to the image of defects in thick sections penetrate thin sections and are converted to intense forward transmitted scatter. In any case, a thick front lead screen is essential to reduce both obtuse scatter and the softer radiation scattered by the steel.

An experiment that demonstrates the superiority of

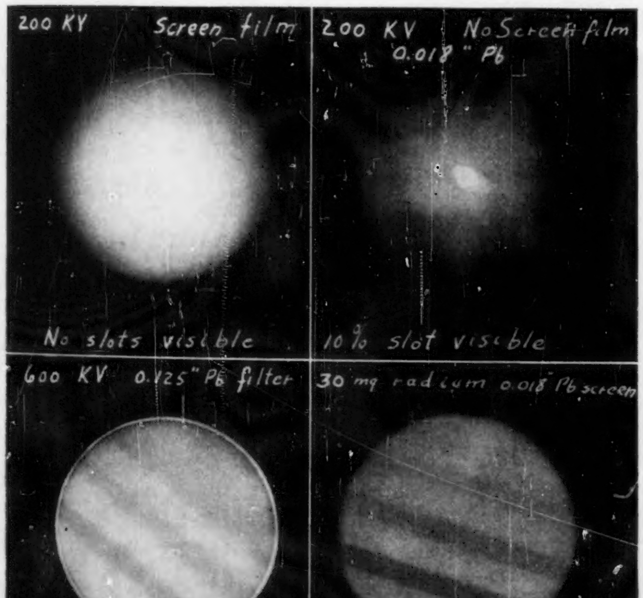


Fig. 1. Superiority of Radium over X-rays for Badly Blocked Castings

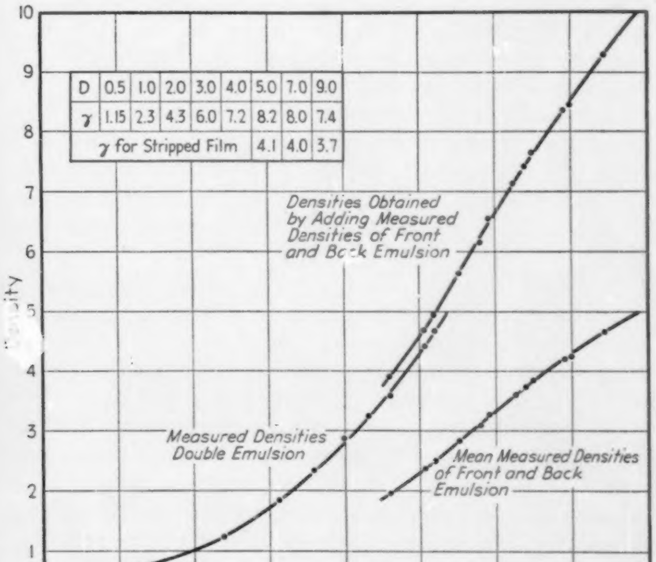
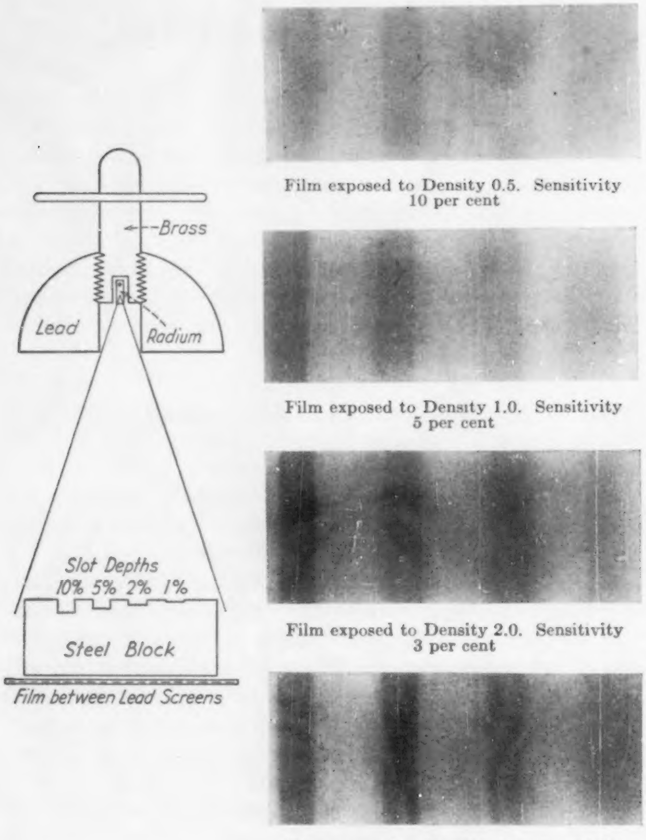


Fig. 2.—Blackening Curve for Noscreen Film Exposed to Gamma Rays, New Kodalk Developer.



Film exposed to Density 0.5. Sensitivity 10 per cent

Film exposed to Density 1.0. Sensitivity 5 per cent

Film exposed to Density 2.0. Sensitivity 3 per cent

Film exposed to Density 3.0. Sensitivity 2 per cent

Fig. 3.—Variation of Sensitivity with Film Density.

radium in this respect is illustrated in Fig. 1. A very simple steel casting[4] was radiographed in such a position that forward transmitted scatter from a $^1/_8$ in. thick dome obscured the image of a 1 in. thick boss. The X-ray pictures are obviously unsatisfactory. The radium picture exposed to a film density of 1.0 is better, but it can be very greatly improved.

Figure 2 shows the characteristic blackening curve of Noscreen film for radium rays. The outstanding feature of this curve is that the emulsion contrast increases continuously up to a film density of over 5.0, and is maintained to densities of over 10.0. Therefore, a great improvement in sensitivity can be gained by using high film densities. This simple but important fact is illustrated by Fig. 3.

Of course, it is not possible to exploit the high contrast available with Noscreen film at high densities with the ordinary type of viewing box. It is necessary to use the highest practical brightness in a viewing box specially designed for this purpose.

The physical and physiological conditions essential to high sensitivity in the viewing of radiographs were presented to Committee E-7 on Radiography in 1940.[5] A viewing box embodying these conditions was described (Fig. 4). This is ideal for routine large area viewing. With the usual No. 2 Photoflood, film densities up to 3.0 can be inspected conveniently.

[4] This simple shape could be blocked to make a group 1 casting, or inverted to make a group 2 casting.

[5] Topical Discussion on Radiographic Testing of Airplane Components, Am. Soc. Testing Mats. (1940). (Issued in mimeographed form as separate publication.)

The limit to the light intensity that can be used in a viewing box is not set by the available power of bulb, but by two other factors. One factor is glare. When a large film area is viewed at one time, light passing through low-density portions prevents satisfactory inspection of high-density portions. Hence it is necessary to reduce the area of the viewing box until only the dense portions of the film are illuminated. The other factor is radiant heat. In addition to discomforting the inspector, excessive heat in the form of infrared radiation will destroy the radiograph. The cheapest and most convenient way of getting a high light-to-heat ratio and high brightness is by using Photoflood lamps.

Polished metals reflect about 95 per cent of infrared radiation and 85 per cent of the visible. White paint reflects about 8 per cent of the infrared radiation and 80 per cent of the visible. Hence, for all viewing boxes, white paint is preferable to metal reflectors. For high intensity viewing boxes, it is necessary to filter the light or to limit the time of viewing to a few seconds.

H. E. Seemann has described a high-intensity viewing box that can be assembled from readily available parts.[6] Two other useful designs of high intensity, small area viewing lamp are shown in Fig. 5.

These lamps are satisfactory for viewing films up to a density of 5.0. The high contrast present in Noscreen film above density 5.0 cannot be used directly, but it is very valuable in another way. In the radiographs of many castings there are large low density images of thick sections together with small areas of high density images of thin sections. The edges of tilted castings often constitute effectively thin sections of this type. The general

[6] Herman E. Seemann, "Trends in the Technique of Industrial Radiography," ASTM Bulletin, No. 115, March, 1942, p. 21.

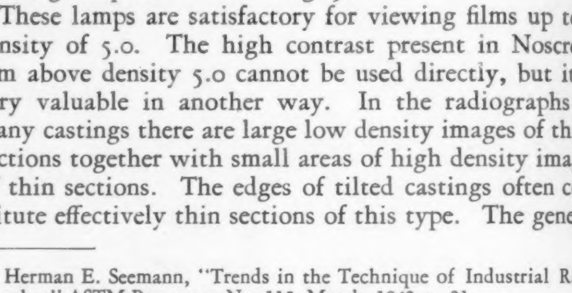


Fig. 4.—Radiographic Viewing Box.

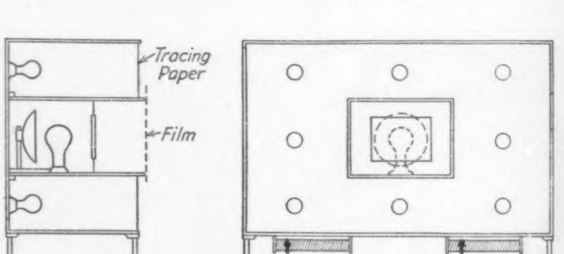


Fig. 5.—High-Intensity Laboratory Lamp and Desk Lamp.

Fig. 6.—Film Stripping Tank.

practice in these cases is either to attempt to include all sections in one film, or to use two films. The one radiograph is bad because the thick areas are relatively underexposed. Two radiographs may be produced either separately, using one short and one long exposure, as in X-ray practice, or together in the same cassette, as in radium practice. Each of these procedures is wasteful when the thin section occupies only a small area of one film. Also while the processes of loading multiple film cassettes and of viewing two films on top of each other are satisfactory, they are rather cumbersome.[7] (One way of reducing the expense of two double-coated films would be to use cheaper single-coated films face to face with lead foil between them.)

To deal with this problem of small areas of density greater than 5.0, experiments were made in stripping the emulsion from one side of the film, and thereby reducing the density to half. Hot and cold water and ammonia applied locally were tried, but the process was too slow for application to a mass-production routine. However, a completely satisfactory way of localized film stripping has been evolved.

Figure 6 illustrates the "stripping tank." It is made with wooden walls and legs, and with a $^1/_4$-in. plate glass bottom. Under the glass, a viewing box is built in and a slide carries light stops between the box and the tank. The tank is filled with water to a depth of 2 in. and the lamps of the viewing box warm the water to about 75 F.

In practice, suitable films are taken from the processing tank and while still on the film hangers, they are viewed under water in the stripping tank. Any areas that appear to be denser than 4.0 are viewed over a small stop and then the emulsion is cleanly and carefully removed from the upper side of the film. For a stripping tool, a flexible curved-end razor blade is excellent. After the local stripping, the film is dried as usual.

The finished film is very convenient for inspection and interpretation of the radiographic images. In particular, the complete images of defects that continue from a thick section of the casting into a thin section can be viewed at one time. In two film techniques, the two portions of such images have to be viewed separately and fitted together in a mental picture or the films have to be cut to fit.

For very large castings, by combining the two-film three-lead screen technique with the stripping process, one radium exposure can be used to inspect an enormous range of metal thickness. In one group of 4000-lb. castings this method was used to inspect a range of 2 to 9 in. at one time. The thickness range 9 to 7 in. was inspected with two films superimposed; the range from 7 to 5 in. with either single film; the range from 5 to 2 in. with a single emulsion on a stripped film. This method was particularly helpful because changing cassettes involved a long journey to the location of the castings.

The same advantage of a single exposure is useful when a foundry is so organized that the radiographer places his films in position just before he leaves in the evening and removes them first thing the following day.

An interesting feature of Noscreen film is that it approaches the ultimate in emulsion contrast. It is very unlikely that any considerable increase in the sensitivity of radium radiography will be provided by future increases in emulsion contrast. Of course, increases in emulsion speed can be expected, but the contrast of Noscreen film has almost reached the limit of any normal photochemical action.

This point can be appreciated by considering the exposure-density curve (Fig. 7). In the density range $D=0.15$ to $D=3.15$ the blackening of Noscreen film is approximately a linear function of exposure. This means that the number of grains affected by a small amount of X-ray energy is almost constant over this range.

The slope of this exposure-density curve K is an index of the speed of the film. The linear relation fixes the emulsion contrast at each film density. Any changes in processing or preparation of the emulsion cannot increase the contrast at a given density beyond that of the "linear film."

Emulsion contrast γ at any density may be defined as the gradient of the characteristic blackening or density—log E curve; *i.e.*, $\gamma = \delta D/\delta \log_{10} E$.*

Since $\delta \log_{10} E = \delta E/E \times 0.434$

$$\gamma = E\ \delta D/\delta E \times 2.30$$

[7] This procedure developed by H. H. Lester and others has the excellent virtue of halving the exposure time required for a given sensitivity.

* Strictly γ is a constant of the emulsion defined by the gradient in the straight line part of the H and O blackening curve. For radiographic film the more general definition is desirable.

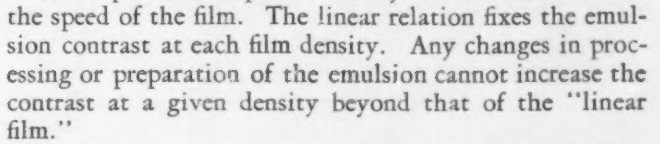


Fig. 7.—Density-Exposure Curve for Noscreen Film Exposed to Gamma Rays, New Kodalk Developer.

In the density range 0.15 to 3.0, Noscreen film approximates to a linear relation between D and E and so we may write for this range

$$D \simeq KE$$

and therefore $\delta D/\delta E \simeq D/E$ at any point.

Hence $\gamma \simeq \delta ED/\delta E \times 2.30$

$$\simeq D \times 2.30$$

For the "linear emulsion" γ is exactly equal to density $\times$ 2.30, that is, at density 1.0 above the background $\gamma = 2.30$; at density 2.0, $\gamma = 4.61$; at density 3.0, $\gamma = 6.91$, and so on. The close approach of Noscreen film to this contrast is shown by the table on Fig. 2. By using a film density of say 3.15, we can achieve more than five times the contrast available at a density of 0.65.

When the emulsion is removed from one side of the film, the contrast is halved.[8] However, half the contrast at density 6.0 is still very much greater than the full contrast at density 0.7.

The conception that radium is a useful inspection tool only for great thickness of metal was long ago shown to be completely without foundation; it must now be abandoned.[9] The combination of the stripping method, high intensity, viewing, and a film that achieves the limiting emulsion contrast, provides an inspection method of great range and adequate sensitivity even for sections of a casting as thin as 1/4 in. For all "badly blocked" castings, radium radiography is the most suitable method of examination.

[8] The secondary effect on contrast of light scattered by the first emulsion falling on the second emulsion can be neglected. The break in the curve of Fig. 1 is due to this effect. For a study of the relation of contrast to angle of incidence, see J. E. de Graaf, "Zur Densitometrie von Röntgenfilmen und ihrer Normung," *Zeitschrift für wissenschaftliche Photographie, Photophysik und Photochemie*, July, 1938, p. 147.

[9] J. T. Norton and A. Ziegler, "Sensitivity of Gamma-Ray Method of Radiography," *Transactions*, Am. Soc. Metals, Vol. 22, March, 1934, pp. 271–288.

Note on the Coincidence of Equations for the Reflectance of Translucent Films

By George W. Ingle[1]

As a part of the "Symposium on Color—Its Specification and Use in Evaluating the Appearance of Materials"[2] held at the Washington Spring Meeting (March 5, 1941) of the American Society for Testing Materials, R. H. Sawyer, Research Division Head, Krebs Pigment and Color Corp., presented a paper on "Hiding Power and Opacity" in which he described the work of Bruce,[3] Kubelka and Munk,[4] and Mills[5] in this field. In the discussion that followed, D. B. Judd, Physicist at the National Bureau of Standards, remarked that although these investigators obtained the same general results, the equations they developed for relating reflectance, contrast ratio, and film thickness seem very different, in spite of the fact that the basic conditions assumed are very similar. He further stated that "some mathematician ought to take . . . these equations . . . and see why they cannot be thrown into exact coincidence."

The following derivation indicates a rationalization of the equations of these investigators.

In 1931 Kubelka and Munk[4] developed equations relating monochromatic reflectivity and thickness of homogeneous translucent materials under completely diffuse illumination. Their general equation is:

$$R = \frac{\left(\frac{1}{R_\infty}\right)(R' - R_\infty) - R_\infty\left(R' - \frac{1}{R_\infty}\right)e^{Sx\left(\frac{1}{R_\infty} - R_\infty\right)}}{(R' - R_\infty) - \left(R' - \frac{1}{R_\infty}\right)e^{Sx\left(\frac{1}{R_\infty} - R_\infty\right)}} \qquad \ldots(1)$$

where

R = reflectance of film at thickness x,
R_∞ = reflectance of film at infinite thickness,
R' = reflectance of background, and
S = scattering coefficient per unit thickness.

Mills reported on the work of Smith[6] and Amy[7] and showed their equations have the general form:

$$R = \frac{e^{Kx} - 1}{\left(\frac{1}{R_\infty}\right)e^{Kx} - R_\infty} \qquad \ldots(2)$$

where K = a constant.

It appears to the author that this latter equation is but a special case of the general Kubelka-Munk equation, that is, that in which R', the reflectance of the background, is zero. If R' in the Kubelka-Munk equation is zero, we have:

$$R_0 = \frac{-1 + e^{Sx\left(\frac{1}{R_\infty} - R_\infty\right)}}{-R_\infty + \left(\frac{1}{R_\infty}\right)e^{Sx\left(\frac{1}{R_\infty} - R_\infty\right)}} = \frac{e^{Sx\left(\frac{1}{R_\infty} - R_\infty\right)} - 1}{\left(\frac{1}{R_\infty}\right)e^{Sx\left(\frac{1}{R_\infty} - R_\infty\right)} - R_\infty} \qquad \ldots(3)$$

so that K, in the Smith and Amy Eq. 2, is equal to $S\left(\frac{1}{R_\infty} - R_\infty\right)$. ($R_0$ represents the reflectance of the film when backed by a material of zero reflectance.) Steele[8] has shown this case of the general Kubelka-Munk equation.

In 1926 Bruce[3] presented a theoretical equation, developed from an earlier theory of Stokes,[9] relating the con-

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[1] Chemist, Color Laboratory, Monsanto Chemical Co., Plastics Division, Springfield, Mass.

[2] Symposium issued as separate publication.

[3] H. D. Bruce, *Technical Paper 306*, Nat. Bureau Standards (1926).

[4] P. Kubelka and F. Munk, *Zeitschrift für technische Physik*, Vol. 12, p. 593 (1931).

[5] H. Mills, *Journal*, Oil, Colour Chemists Assn., Vol. 23, p. 245 (1940).

[6] T. Smith, *Transactions*, Optical Soc. (London), Vol. 33, p. 150 (1931).

[7] L. Amy, *Revue d'Optique*, Vol. 16, No. 3, March, 1937, pp. 81–85.

[8] F. A. Steele, *Paper Trade Journal*, Vol. 100, No. 12, pp. 37–42 (1935).

[9] Sir G. G. Stokes, Mathematical and Physical Papers, Vol. 4, p. 145 (1862).

trast ratio and film thickness of a paint:

$$Y = \frac{\dfrac{(ab^{2x} - a)}{(a^2b^{2x} - 1)} + \left[\dfrac{a^2b^x - b^x}{a^2b^{2x} - 1}\right]^2 R_B \left[1 - \dfrac{(ab^{2x} - a)R_B}{(a^2b^{2x} - 1)}\right]^{-1}}{\dfrac{(ab^{2x} - a)}{(a^2b^{2x} - 1)} + \left[\dfrac{a^2b^x - b^x}{a^2b^{2x} - 1}\right]^2 R_W \left[1 - \dfrac{(ab^{2x} - a)R_W}{(a^2b^{2x} - 1)}\right]^{-1}} \quad \ldots\ldots(4)$$

where

Y = contrast ratio (ratio of reflectance of material backed by black to that backed by white),
x = film thickness,
R_B = reflectance of black background,
R_W = reflectance of white background, and
a and b = constants in the Stokes' equation.

Stokes theorized that the reflectance and transmission of a pile of m glass plates of equal thickness would be represented by

$$R = \frac{b^m - b^{-m}}{ab^m - a^{-1}b^{-m}} \quad \ldots\ldots(5)$$

and

$$T = \frac{a - a^{-1}}{ab^m - a^{-1}b^{-m}} \quad \ldots\ldots(6)$$

where a and b are constants which bear a functional relationship to the fraction of light reflected by and transmitted through each plate, respectively. Bruce applied this theory to thin films of paint, the thickness x of which he considered proportional to m. If such a film were backed by a material of reflectance R', and all re-reflectance occurring at the two film surfaces were considered, the total light ϕ reflected from the film surface would be represented by

$$\phi = R + \frac{T^2R'}{1 - R'R} \quad \ldots\ldots(7)$$

provided unit flux is incident. By direct substitution of Stokes' equations for R (Eq. 5) and T (Eq. 6), in terms of x, the film thickness, and the two reflectances R_B and R_W used in determining contrast ratio, into Eq. 7, the foregoing intricate Eq. 4 was developed.

As in the case of the Smith-Amy equation, Stokes' equation is a special case of the general Kubelka-Munk equation, that is, that in which the reflectance of the background of the pile of m glass plates is zero. The Stokes' equation for R_0 may be simplified:

$$R_0 = \frac{b^m - b^{-m}}{ab^m - a^{-1}b^{-m}} = \frac{a(b^{2m} - 1)}{(a^2b^{2m} - 1)} = \frac{(b^{2m} - 1)}{a\left(b^{2m} - \dfrac{1}{a^2}\right)} \quad \ldots\ldots(8)$$

The structural similarity of this last expression to Eqs. 2 and 3 is immediately apparent, particularly when Eq. 2 is written in the form

$$R = \frac{e^{Kx} - 1}{\left(\dfrac{1}{R_\infty}\right)(e^{Kx} - R_\infty^2)} \quad \ldots\ldots(9)$$

On this basis,

$$a = \frac{1}{R_\infty} \quad \ldots\ldots(10)$$

and

$$b^{2m} = e^{Kx} \quad \ldots\ldots(11)$$

Since $e^{K_t x}$ may be equated to transmission, according to Bouguer's (or Lambert's) law, these expressions indicate the functional relationships existing between these constants and reflectance and transmission.

The indicated relationship between the constant b and the light transmitted may be more clearly demonstrated by representing b by e^{K_b}, so that, without violating the proportionality of m and x, or the equality of K and $S\left(\dfrac{1}{R_\infty} - R_\infty\right)$, we have:

$$b^{2m} = e^{K_b 2m} = e^{Kx} = e^{Sx\left(\frac{1}{R_\infty} - R_\infty\right)} \quad \ldots\ldots(12)$$

from which, if m is equal to x,

$$2K_b = K = S\left(\frac{1}{R_\infty} - R_\infty\right) \quad \ldots\ldots(13)$$

If the equalities in Eqs. 10 and 12 are substituted for the proper terms in the Kubelka-Munk equation (Eq. 1), we obtain, for the case in which the film is backed by a black material of reflectance R_B,

$$R_{RB} = \frac{a\left(R_B - \dfrac{1}{a}\right) - \dfrac{1}{a}(R_B - a)b^{2m}}{\left(R_B - \dfrac{1}{a}\right) - (R_B - a)b^{2m}} \quad \ldots\ldots(14)$$

This expression may be simplified by expanding and collecting terms to obtain:

$$R_{RB} = \frac{(ab^{2m} - a) + R_B(a^2 - b^{2m})}{(a^2b^{2m} - 1) - R_B(ab^{2m} - a)} \quad \ldots\ldots(15)$$

By dividing both numerator and denominator of this fraction by the term $(a^2b^{2m} - 1)$, we have:

$$R_{RB} = \frac{\dfrac{(ab^{2m} - a)}{(a^2b^{2m} - 1)} + \dfrac{(a^2 - b^{2m})R_B}{(a^2b^{2m} - 1)}}{1 - \dfrac{(ab^{2m} - a)R_B}{(a^2b^{2m} - 1)}} \quad \ldots\ldots(16)$$

from which, in turn, by performing the indicated division, we obtain:

$$R_{RB} = \frac{(ab^{2m} - a)}{(a^2b^{2m} - 1)} + \frac{\left[\dfrac{(a^2 - b^{2m})}{(a^2b^{2m} - 1)} + \left\{\dfrac{(ab^{2m} - a)}{(a^2b^{2m} - 1)}\right\}^2\right]R_B}{1 - \dfrac{(ab^{2m} - a)R_B}{(a^2b^{2m} - 1)}} \quad \ldots\ldots(17)$$

By expanding and collecting terms, the numerator of the remainder may be simplified to:

$$\left[\frac{(a^4b^{2m} - 2a^2b^{2m} + b^{2m})}{(a^2b^{2m} - 1)^2}\right]R_B = \left[\frac{(a^2b^m - b^m)}{(a^2b^{2m} - 1)}\right]^2 R_B \quad \ldots(18)$$

so that (Eq. 17) becomes:

$$R_{RB} = \frac{(ab^{2m} - a)}{(a^2b^{2m} - 1)} + \frac{\left[\dfrac{(a^2b^m - b^m)}{(a^2b^{2m} - 1)}\right]^2 R_B}{\left[1 - \dfrac{(ab^{2m} - a)}{(a^2b^{2m} - 1)} R_B\right]} \quad \ldots\ldots(19)$$

If m is equal to x, Eq. 19 is the numerator in Bruce's equation for contrast ratio. The derivation of the corresponding denominator (the reflectance of the film when backed by a white material of reflectance R_W) is directly analogous, R_W being substituted for R_B.

The Electron Microscope and Its Uses[1]

By R. Bowling Barnes[2] and Charles J. Burton[2]

SINCE THE DAWN of civilization Man has been driven forward by an insatiable curiosity. Instinctively a child desires to break up his mechanical toy in order to see for himself what really makes it run. A sign reading "Wet Paint" serves only to excite Man's desire to investigate. A strange phenomenon, a cross-word puzzle, or a new gadget carefully sealed and enclosed, presents to the mind a challenge and an invitation to a bit of original research. In fact, it can be truly said that human progress results from the desire to obtain, in spite of difficulties and early failures, the answers to the questions, where? when? how? why? and what?

Of our five senses, certainly one of the most useful has been the ability to see. One look through Galileo's telescope and there was born a desire to see more clearly things at greater and greater distances. No longer was Man content to observe the beauties of the night sky with the unaided eye; the desire to see more of these heavenly bodies, and thus to know their secrets, became a tremendous driving force. First one apparent limit of perfection in the art of constructing telescopes and then another was reached and passed; now the world is anxiously awaiting the first results from the giant 200-in. instrument at Mt. Palomar. One look through Leeuwenhoek's crude microscope at a new world of minute dimensions and there was born a wish to see clearly objects of fantastic smallness. Again a challenge had been presented and this challenge grew to be a demand; this demand for more perfect instruments resulted in research, which in turn caused the original desire to become even more impelling. Until recently, however, the ultimate limit in this direction appeared to have been reached. Further research, however, performed because Man refused to be satisfied, has now enabled us, by means of the electron microscope, to see objects 50 to 100 times smaller than this limit—and still research goes on. Additional improvements in the technique of seeing will surely follow.

Little did Oersted dream, when he first observed the interaction of an electric current and a magnetic field, that the fact so easily taught freshmen by means of the three-finger rule, Fig. 1, would in the 1900's become the basis for such tools of research as the mass spectrograph, the cyclotron, the betatron, the iconoscope, or the electron microscope. Nor did we realize, when we first studied physics, that this rule might later be used to explain any device more complicated than a motor or a generator.

Sir J. J. Thomson first proved the existence of the electron late in the last century; de Broglie in 1924 showed that it behaved as if it were accompanied by waves; Schrödinger contributed much to a better understanding of its nature; and Busch in 1926 showed that a stream of electrons upon passing through the magnetic field of a solenoid could be focused in much the same way that a beam of light is focused by a reading glass. The electron lens and the field of electron optics were thus created. A combination of these lenses put together by Knoll and Ruska in 1932 gave the world its first electron microscope. In December, 1940, R.C.A. delivered to our laboratory the first electron microscope commercially built in this country. With it, during the first year of its operation, some 4000 successful electron micrographs were made. Many objects commonly used were really "seen" for the first time; many theories were proved and some disproved; new points of view were created in the minds of scientists studying these photographs; in many cases structural details as small as 40 Å were revealed; important discoveries have already been made in many fields of science. In spite of the vast multitude of wonderful achievements of this age, this instrument, the result of the combined efforts of many individuals, must certainly be looked upon as one of major importance.

Frequently, one is asked the reason for the change from light to electrons. The answer is simple, and is founded

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[1] Some of the material in this paper was presented as an address before the annual meeting of the American Society for Testing Materials, in Chicago, Ill., June 26, 1941.

[2] Stamford Research Laboratories, American Cyanamid Co., Stamford, Conn.

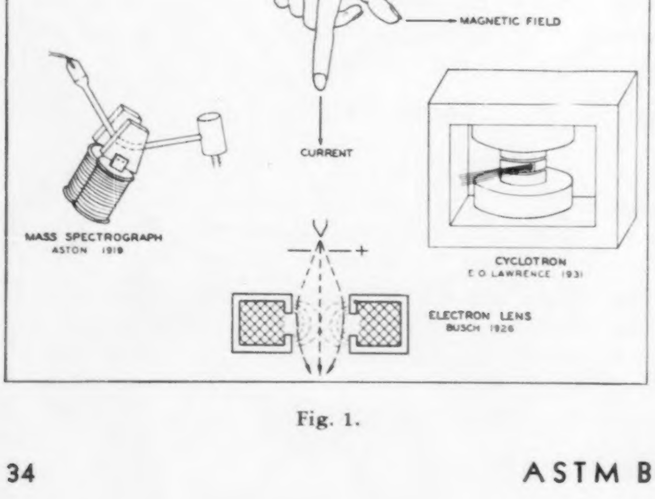


Fig. 1.

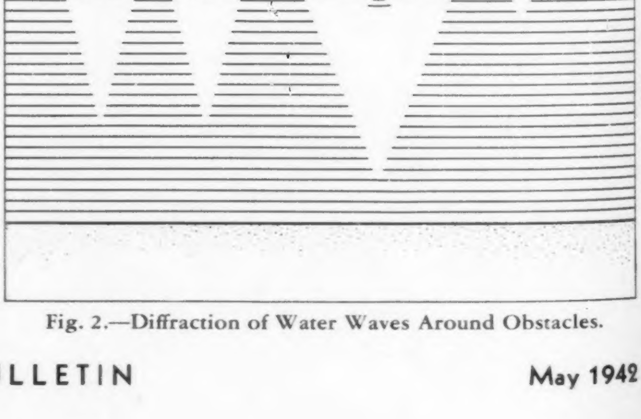


Fig. 2.—Diffraction of Water Waves Around Obstacles.

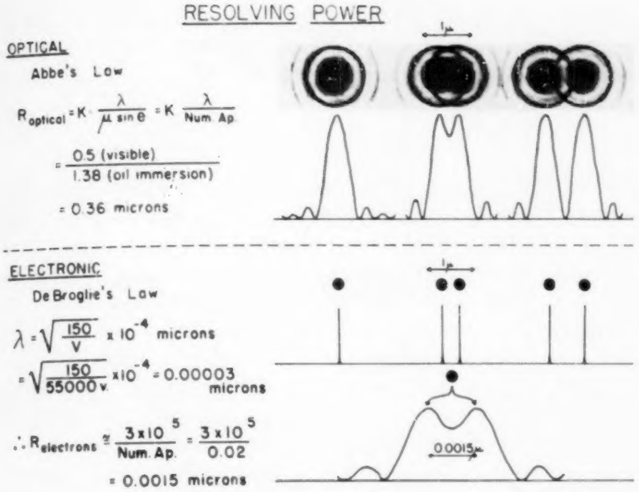


Fig. 3.—A Comparison of Resolving Powers of the Optical and Electron Microscopes.

The upper diagram shows the diffraction patterns produced optically by a single particle, by two particles just resolved, and by two particles completely resolved. The lower diagram indicates that with particles separated the same distance the diffraction patterns produced by electrons are negligible in size because of the extremely small electronic wave length. Two particles only 0.0015 μ apart are theoretically resolvable by the electron microscope.

upon the necessity for obtaining a higher degree of resolving power beyond the farthest limit possible using light, this limit being imposed by the wave nature of light itself.

In his attempts to understand the nature and behavior of light, Huygens found it convenient to study the waves produced upon the canals of Holland by a passing boat. A similar study may be useful at this point.

Let us imagine a steady progression of uniform waves rolling up against the shore, as shown in Fig. 2. Assume that a large object, say a portion of a sea wall about 50 ft. long, exists just off shore. As seen from above, there would be a quiet region immediately behind this barrier where no waves existed and we could, from our observations of the disturbed wave fronts alone, deduce the fact that an object was present in the path of the waves; in fact, the length of the object could be ascertained.

Suppose further that two such wall sections were separated by many feet. We would know readily that two were present and we could determine their separation. If, however, this separation were smaller than a certain critical amount, which is a function of the distance between the crests of successive waves, we would know that something had interfered with the progress of the waves, but we would not have any basis for stating that in reality two objects were present; we could not resolve the effects produced by the two wall sections.

Farther down the beach, suppose shorter and shorter lengths of wall existed. Below a certain length we would, merely by observing the surface of the water, fail

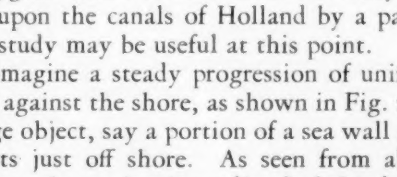


Fig. 4.—Effect of Oblique Illumination on Inclusion of Diffracted Rays by an Objective.

entirely to detect the presence of these objects. The wave length of the water waves is too long to reveal the presence of the relatively small obstacles.

These phenomena are diffraction effects and result from the inherent wave nature of the medium used for our observations. Unfortunately, their exact counterparts may be found when light waves are used; hence, the limitation referred to above. In order to see small objects clearly, we must have resolving power sufficient to reveal clearly their shape, size, and structure; we must know whether we are looking at one particle or at two located very close to each other. Practically, the resolving power of optical systems is limited to about one half the wave length of the light used.

Every student of optics is taught that each point in an object is portrayed by an optical instrument as a diffraction disk, the diameter of this disk being a function of the wave length of the light used and the geometry of the lenses of the instrument. A photograph of a star, which to all intents is a single point, appears upon enlargement to be a round disk surrounded by alternately dark and light rings; this shape and these rings result from the diffraction effects referred to above. Rayleigh showed that an optical system could just resolve two such points when they were separated by a distance such that the center of the diffraction disk of one just coincided with the first dark ring (diffraction minimum) of the other, as in Fig. 3. This limit of the theoretical resolving power is expressed for the case of a microscope in Abbé's classical formula:[3]

$$R_{\text{Theoretical}} = \frac{1.22\,\lambda}{\mu \sin\theta} = \frac{1.22\,\lambda}{N.A.}$$

where λ is the wave length of the light and $N.A.$ is the numerical aperture of the objective used. Thus, using visible blue-green light ($\lambda = 0.5\ \mu$) and an oil immersion objective ($N.A. = 1.38$) it is clear that two points in the object being observed or two small objects can just be seen as two when the distance between their centers is equal to Abbé's limit, or equal to

$$R = \frac{1.22 \times 0.5}{1.38} = 0.44\ \mu$$

In order to be able to see still smaller objects we must either decrease λ or increase $N.A.$ Remembering, however, that $N.A. = \mu \sin\theta$ where μ is the refractive index of the medium between the object and the objective (μ for cedar wood oil = 1.55) and θ is the angle between the central ray from the object and the outer ray caught by the objective (θ for the 3-mm. objective = 63 deg.; $\sin\theta = 0.89$), it is clear that it is practically impossible to increase $N.A.$ much beyond 1.38. By using ultraviolet light (λ as low as 0.25 μ) we can reduce the limiting resolvable distance to half the value for visible light, or to about 0.22 μ. A further reduction by a factor of about 2 is possible with the use of oblique light since the effective angle θ can be increased. This is shown more clearly in Fig. 4 in which, with oblique illumination, both the direct ray and one of the diffracted rays are included by the objective, thereby increasing the resolution. Even so, it is clear that the ultimate theoretical limit which actually has been reached, is still above 0.1 μ. Hence, in following the driving force of our desire and need to see clearly still

[3] Abbé's classical formula originally omitted the constant 1.22.

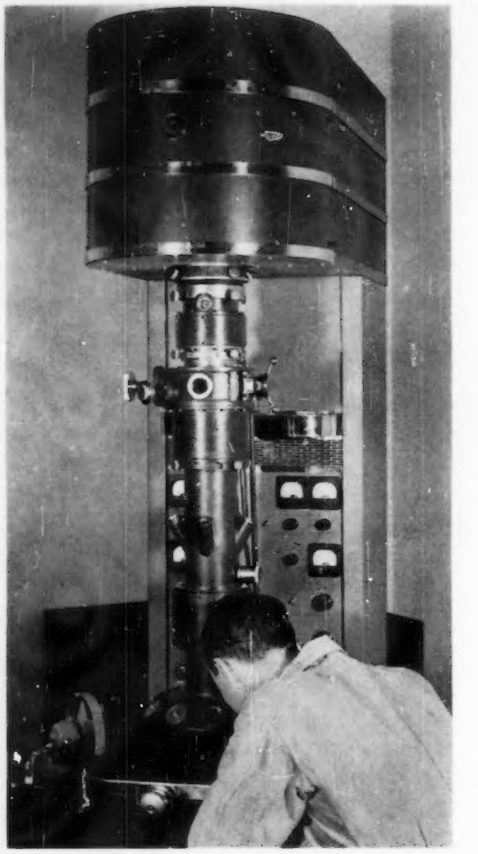


Fig. 5.—The Electron Microscope in Use in the Laboratories of the American Cyanamid Co.

smaller and smaller objects or details in objects just visible, it was necessary to abandon the use of light.

As mentioned above, de Broglie showed that an electron in motion is accompanied by waves of length $\lambda = \sqrt{\frac{150}{V}}$, where V is the accelerating voltage, and λ is in Ångstrom units. It is practical to use accelerating potentials of 55,000 v., and thus have a beam of electrons whose effective wave length is only 0.000055 μ or $^1/_{45,000}$ that of the

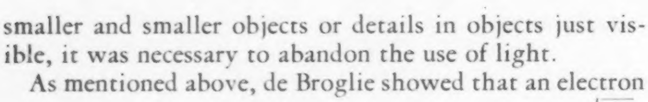


Fig. 6.—Schematic Outline of the Electrical Equipment.
The cathode is actually heated by a rectifier-filter system rather than by the battery indicated above.

shortest practical ultraviolet. Busch showed that such a beam of electrons could be focused by the magnetic field of a solenoid. This combination of facts led to an obvious conclusion—the electron microscope.

The Electron Microscope

The construction and use of an electron microscope (see Figs. 5 and 6) are not unattended by difficulties. Electrons have little penetrating power; hence only thin objects can successfully be studied. Electrons are easily scattered; therefore the entire microscope must be evacuated. A stream of fast moving electrons if stopped suddenly by an object produces considerable heat; hence many objects are destroyed while being observed. The effective focal length of an electron lens is dependent upon the strength of its magnetic field and so upon the current; thus severe requirements are imposed upon the stability of the electrical circuits. Unlike the behavior of light in a glass lens, the path taken by electrons in the magnetic field of an electron lens of fixed focal length is a function of their velocities; hence the accelerating voltage must be kept constant in order to avoid the analogue of chromatic aberration. To minimize spherical aberration, an aperture only 20 μ in diameter is used. Table I shows the errors encountered in the electron microscope and the steps which must be taken to eliminate or to minimize them.

Although these and other difficulties have not yet been entirely overcome, the manufacturers of the present microscope have gone far in this direction. It is not too difficult

TABLE I.—POSSIBLE SOURCES OF ERROR AND STEPS TAKEN TO ELIMINATE THEM.

1. Diffraction of electron wave	1. ....
2. Spherical aberration	2. Use of small objective aperture
3. Mutual repulsion of electrons	3. Use of high velocity electrons
4. Fluctuations of magnetic fields of lenses (analogous to changes of curvature of glass lenses)	4. Proper power supply regulation Objective lens current 0.0075% Projection lens current 0.068% Condenser lens current 0.1%
5. Chromatic aberration due to fluctuations of accelerating voltage	5. Proper regulation of high voltage supply; better than 0.002%
6. Chromatic aberration due to straggling of electron velocities in object	6. Use of thin objects and specimen supports
7. Errors due to scattering of electrons at the object	7. ....
8. Spurious magnetic field (for example, stray fields)	8. Careful magnetic shielding

TABLE II.—COMPARISON OF MAGNIFIERS.

Instrument	Numerical Aperture	Focal Length, mm.	Useful Magnification Diameters	Depth of Focus,[a] μ	Limit of Resolution,[b] μ
Eye	0.01	..	1	...	100–200
Hand lens	0.1 ±	25	10	40	20
Binocular microscope	0.1	32	40	24	5
Research microscope	0.25	16	100	4	2
Research microscope	0.50	8	200	0.9	1
Research microscope	0.85	4	350	0.2	0.6
Research microscope	0.95	4	400	0.08	0.52
Oil immersion objective (4200 Å)	1.38	3	700	0.06	0.30
U. V. objective (2700 Å)	1.38	3	1 000	0.04	0.20
Electron microscope	0.02	5	100 000	1.5	0.005

[a] Depth of focus calculated for circle of confusion of 50 μ.
[b] Figures given for axial illumination; may be halved by employing oblique illumination.

TABLE III.—COMPARISON OF SIZES OF FAMILIAR OBJECTS.

	Natural Size, mm.	Size of Image at 1000 ×, mm.	Size of Image at 100,000 ×
Average human hair	0.06	60	600 cm.
Particles just visible	0.1	100	1000 cm.
Red blood cells	0.008	8	80 cm.
Ragweed pollen grains	0.01	15	150 cm.
Cocci (round bacteria)	0.002	2	20 cm.
Air-borne dust (average)	0.002	2	20 cm.
Colloidal particles	0.0003 to 0.000002	0.3 to 0.002	30 mm. to 0.2 mm.
Simple molecules	0.000003	0.003	0.3 mm.
Atomic dimensions	0.0000002	0.0002	0.02 mm.

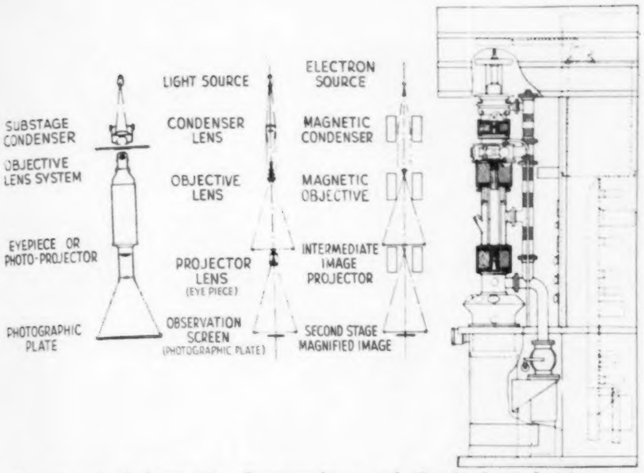


Fig. 7.—A Schematic Comparison of Optical and Electron Microscopes.

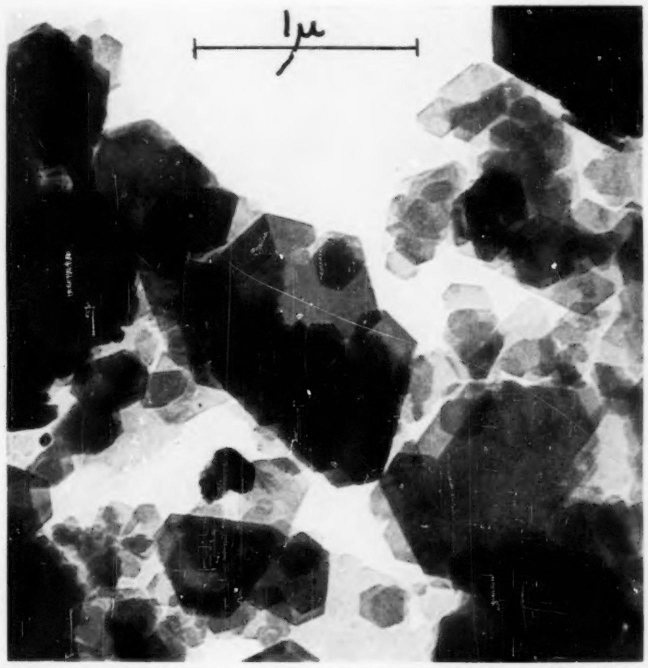


Fig. 8.—Kaolinite Which Shows Clearly the Overlapping of the Platelets (× 30,000).

to obtain clearly resolved details of the order of 40 Å or 0.004 μ, thus bettering the performance of light microscopes some hundredfold.

The unaided eye can resolve details separated by 0.1 to 0.2 mm. Accordingly, if the image produced by an objective does not contain details smaller than 0.1 mm., subsequent magnification is not useful. Actually, the maximum direct magnification of the electron microscope is about 30,000×. Since, however, electron micrographs generally do contain detail too small to be seen by the unaided eye, it is beneficial to magnify them still further by auxiliary optical means. Indeed, total magnifications of 100,000× are described by many observers.

Too often, in discussions of this instrument, emphasis has been placed only upon the extremely high magnifications possible. Actually, the two most important features are the increased resolving power and the abnormally great depth of focus. All who have examined photomicrographs at 1000 diameters or thereabouts are familiar with the fact that not all objects in the field are in sharp focus. Since this property is a function of the reciprocal of the numerical aperture (*N.A.*), the small value for the electron microscope (*N.A.* = 0.02) gives it a remarkable depth of focus. Thus, all parts of an electron micrograph are in sharp focus. A comparison of the resolving power and depth of focus of various optical microscopes with those of the electron microscope is given in Table II.

In order to understand that an instrument, capable of such magnifications, has opened for our intimate study an entirely new dimensional work, a comparison of the sizes assumed by familiar objects at 100,000× may be useful, and is shown in Table III.

The component parts of the electron microscope form a surprisingly close analogy with the essential parts of a light microscope as may be seen from Fig. 7. Each of the essential parts of one may be found in the other. It is perhaps worth pointing out, however, one interesting difference between the two instruments. The optical microscope makes use of fixed focal-length lenses and focusing is achieved by varying the object distance. In the electron microscope, on the other hand, all of the distances are fixed and a focus is obtained by varying the focal length of the magnetic objective lens until a sharp image is seen.

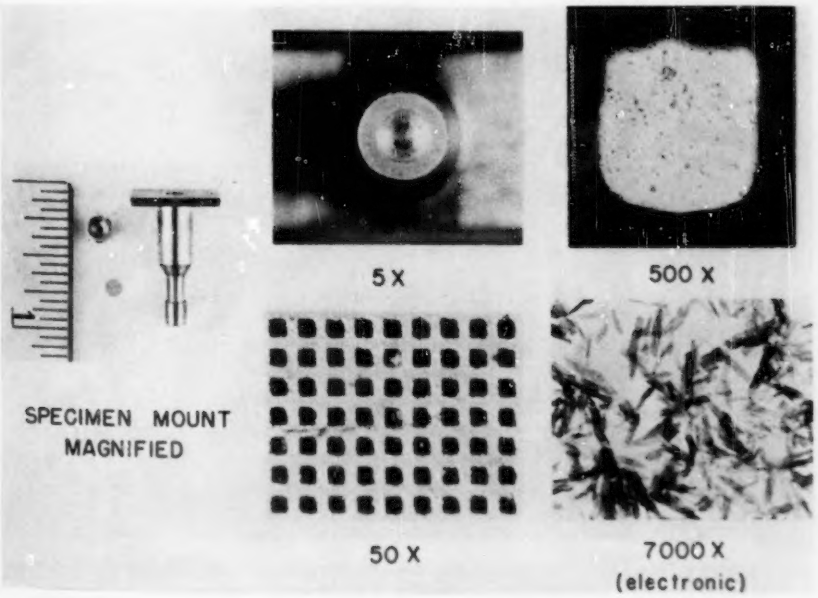
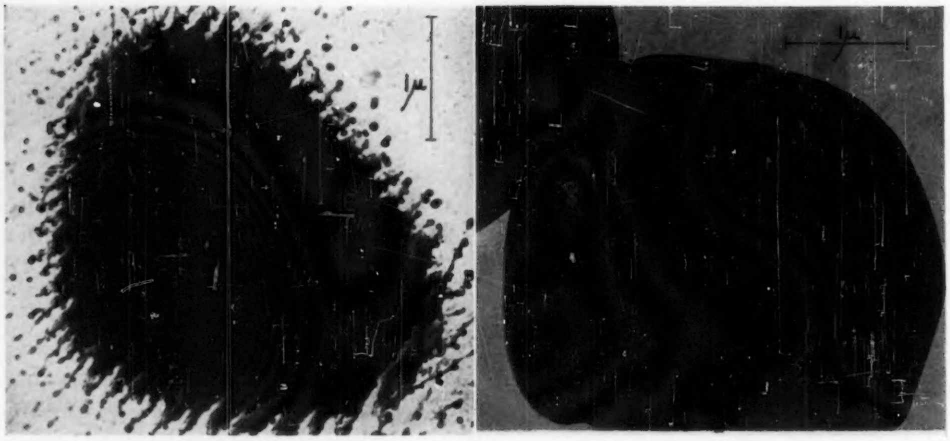


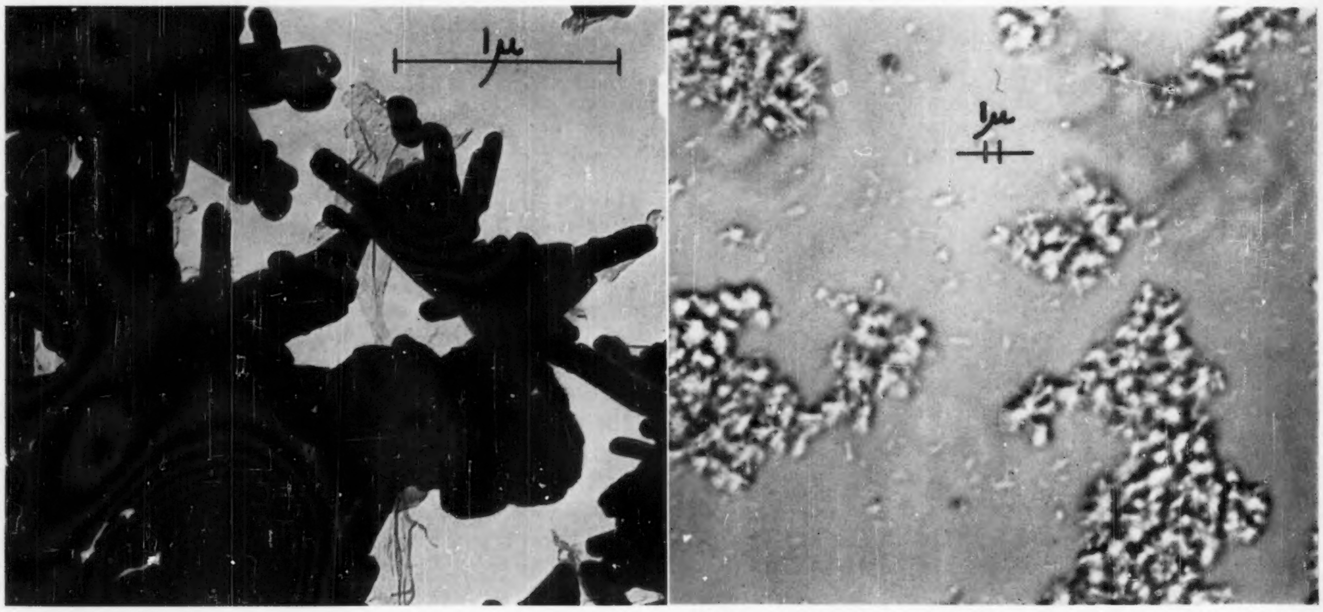
Fig. 9.



(a) (b)

Fig. 10.—Electron Micrographs of Sulfur Particles.

(a) Particle which has been partially destroyed under the electron beam. (b) Particle unaffected by electron irradiation.



(a) Electron micrograph (× 30,000) of precipitated calcium carbonate (aragonite).

(b) Photomicrograph (× 2000) of same sample of precipitated calcium carbonate (aragonite).

Fig. 11.—Comparison of Electron Micrograph and Photomicrograph.

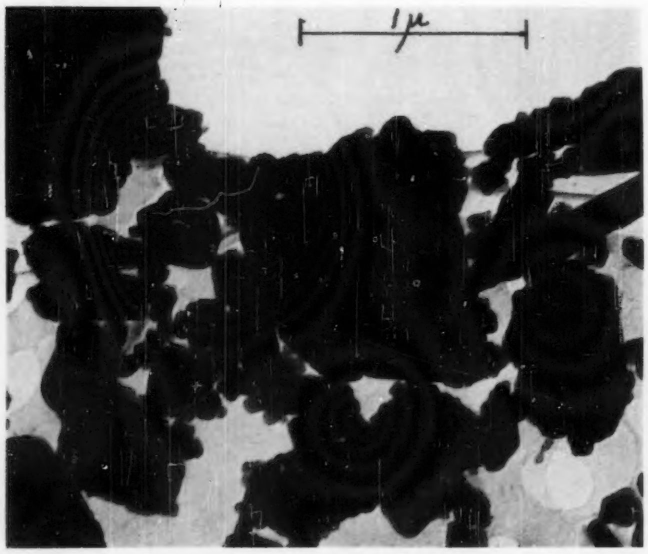


Fig. 12.—Calcite Form of Calcium Carbonate (× 30,000).

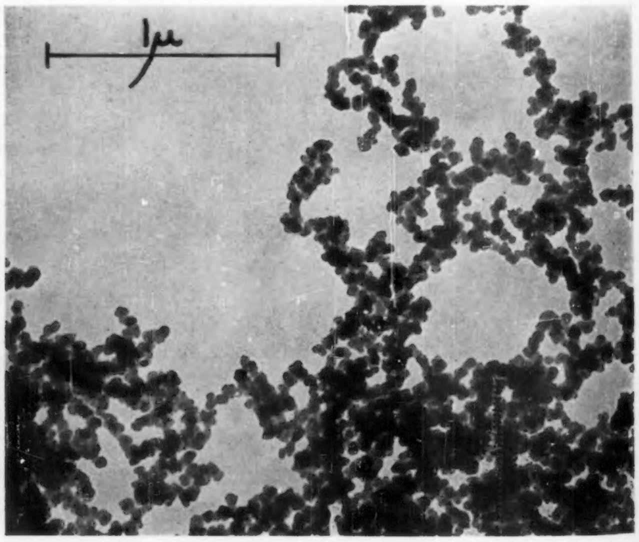


Fig. 13.—Carbon Black Prepared by Burning Benzene (× 30,000).

Fig. 14.—Aluminum Smoke Prepared by Burning Metallic Aluminum in an Electric Arc (× 30,000).

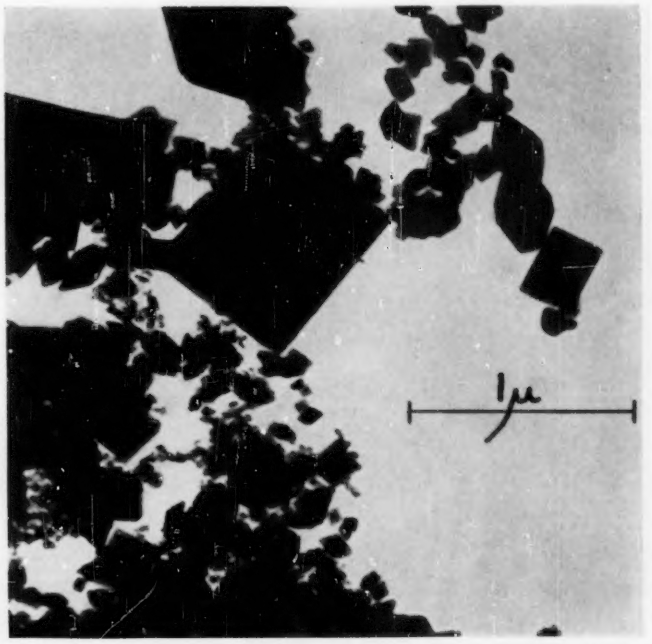


Fig. 16.—Tungsten Oxide Smoke Prepared by Burning Tungsten Wire in an Electric Arc (× 30,000).

The image of the object, which is seen on the fluorescent screen and which may be photographed, is produced by those electrons which are not absorbed or scattered by the object. These two phenomena are functions of the product of density times thickness of the object. It must be stressed that the electron image is not produced by differences in refractive index as in the case of light images, but rather by differences in the amount and kind of matter traversed by the electrons. These images need not be mere silhouettes, for, by employing proper photographic technique, all of the half tones of an ordinary photograph may be shown, provided the electron absorption of the specimen is sufficiently low. Thus, different densities in the final electron micrograph will represent either different densities, different thicknesses, or different combinations of the two, in the object. This effect may be seen very clearly by examining carefully Fig. 8, which shows the overlapping platelets of ordinary kaolin.

The photographs actually obtained are usually 2 by 2 in. Since the microscope is most conveniently focused by observing the visible image produced upon the fluorescent screen, it has ordinarily been found desirable to photograph at some magnification between 10,000× and 15,000× and not at 30,000×. This is based upon the

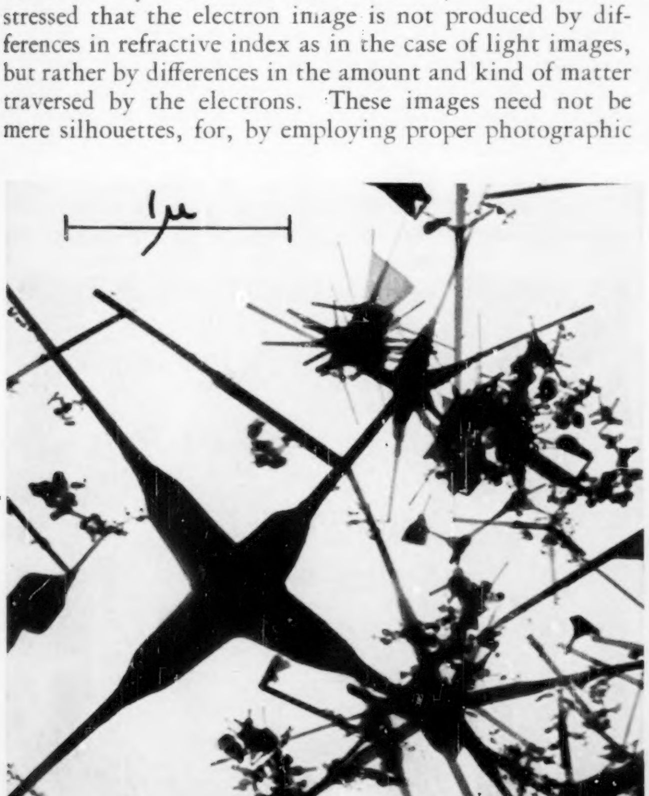


Fig. 15.—Zinc Oxide Smoke Prepared by Burning Metallic Zinc in an Oxygen Flame (× 30,000).

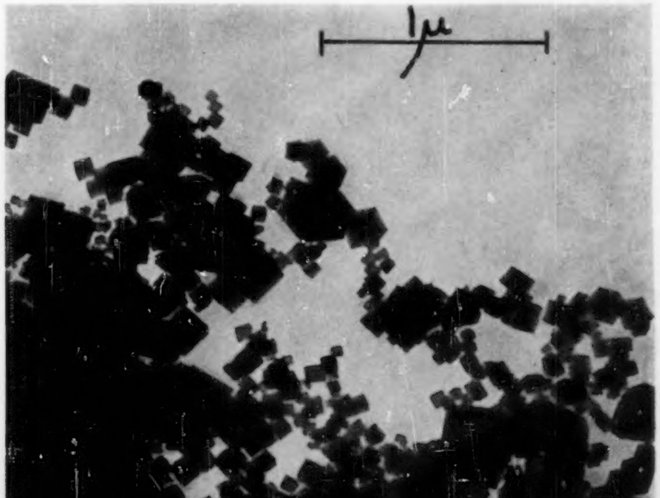


Fig. 17.—Magnesium Oxide Smoke Prepared by Burning Magnesium Ribbon (× 30,000).

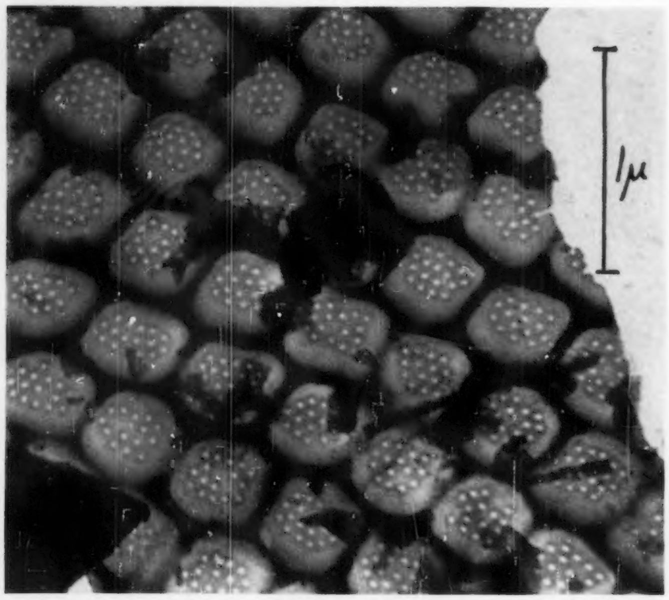


Fig. 18.—Diatom Found in Commercial Sample of Diatomaceous Earth (× 30,000).

fact that the intensity of the image used for focusing and the diameter of the field photographed each varies inversely with the magnification. It is further true that photographs taken at these magnifications possess sufficient well-resolved detail to warrant subsequent optical magnifications of from four to eight times.

Obviously, photographs 2 by 2 in. taken at these magnifications can cover only an extremely small field; at 15,000×, for example, the image seen at one time represents a rectangular part of the object screen only 3.4 by 3.4 μ. In view of the dimensions involved and the fact that the object carrier must be a membrane of some substance

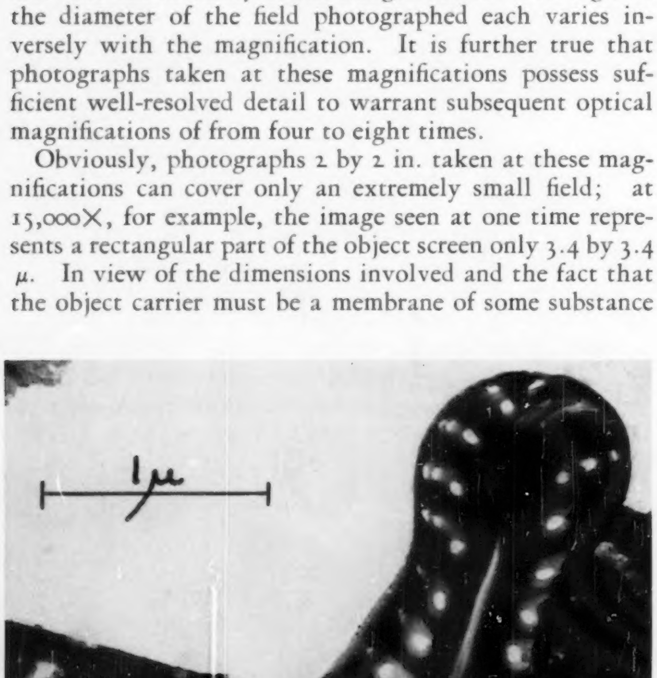


Fig. 19.—Diatom (× 30,000).

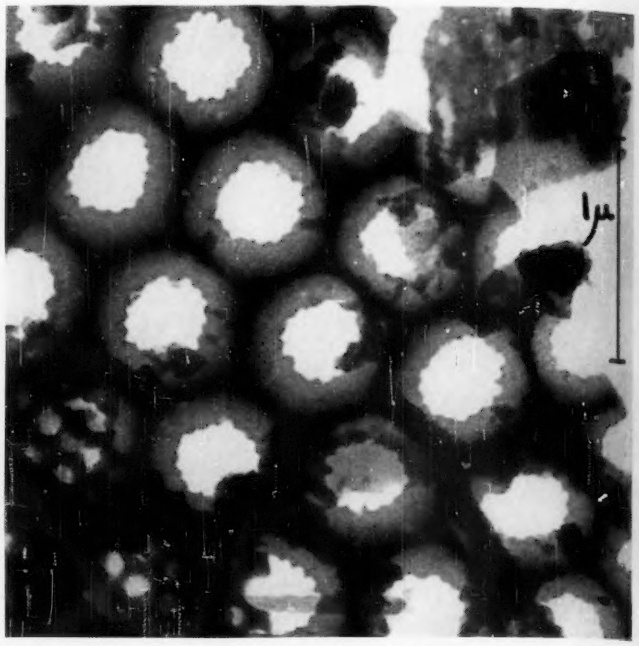


Fig. 20.—Diatom (× 30,000).

approximately only 0.01 μ thick, it is clear that the technique of mounting specimens for observation requires some study. Figure 9 shows the type and size of the holder used. The wire screen is 200 mesh, and is covered by an extremely thin nitrocellulose film upon which the objects to be studied are deposited.

The results shown have been chosen with a view to illustrating the wide scope of usefulness of the microscope in the field of extremely small particles.

Figure 10 shows electron micrographs of two kinds of sulfur particles. Obviously, one of these has suffered severely under the impact of the electron beam, as is shown by the total loss of shape. This, unfortunately, is typical of many kinds of matter; it is never possible to prophesy with certainty, before introducing a given object into the

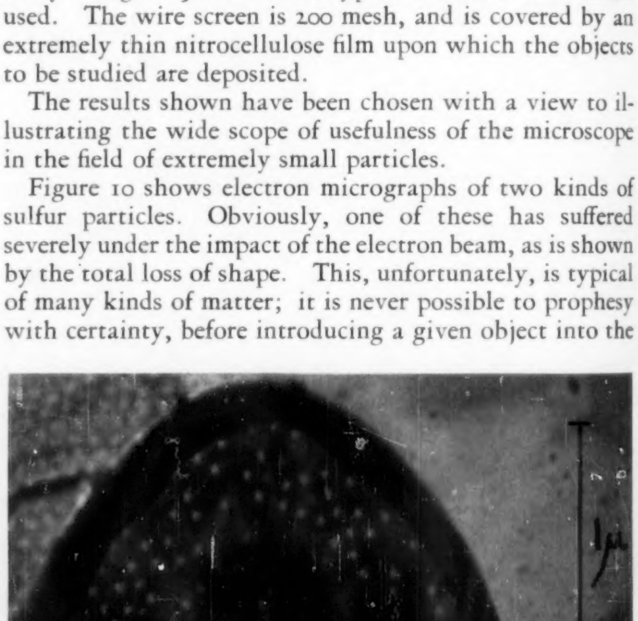


Fig. 21.—Foreign Material, Presumably a Diatom, Found in Commercial Carbon Black (× 30,000).

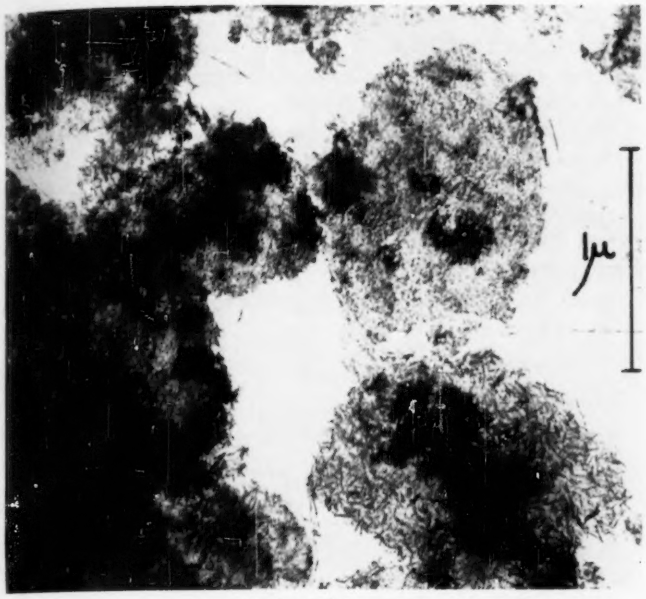


Fig. 22.—Partially Hydrated Magnesia (× 30,000).

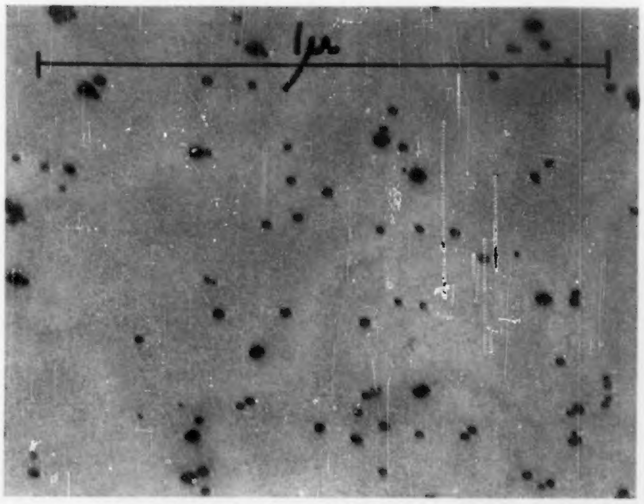


Fig. 23.—Colloidal Gold Particles (× 75,000). Average gold particle is approximately 125 Å in diameter.

microscope, whether it will be able to survive the ordeal of having its photograph taken by this new method.

In Fig. 11 a comparison of a photomicrograph at 2000× and an electron micrograph at 30,000× is shown, the subject matter in each case being the same sample of calcium carbonate (aragonite). Attention is called to the great differences in the degree of resolution, the depth of focus, and the relative sizes of the field. As a result of the clarity and sharpness of the electron micrograph one sees immediately the value of this instrument in the study of small objects. From photographs of this quality, many conclusions regarding the exact size, shape, porosity, thickness, etc., of small particles can be drawn. Figure 12 shows the calcite form of calcium carbonate.

Figures 13, 14, 15, 16, and 17, respectively, show electron micrographs of carbon black, aluminum particles, zinc oxide, tungsten oxide, and magnesium oxide.[4] Careful examination of the last photograph shows the ability of this microscope to reveal internal details of crystals. The delicate photographic shadings within a single crystal correspond to variations in the thickness of material traversed by the electrons. Since these crystals are cubes oriented at random, every projected image is different.

Figures 18, 19, and 20 show three of the many forms of diatoms which have been studied. Figure 21, an object which was found in a commercial sample of carbon black, is presumably also a diatom.

The photograph of magnesia, Fig. 22, is particularly interesting inasmuch as the centers of some of the small particles are separated by only 40 Å.

The electron micrograph of colloidal gold, Fig. 23, in which the individual gold particles are known to be of the order of 125 Å in diameter, clearly illustrates the tremendous resolving power which we have available in the electron microscope.

At this time, it is still too early to predict just exactly what role the electron microscope will ultimately play in the affairs of this Society. There can, however, be little doubt that many important researches will be furthered, many mysteries clarified, and many existing concepts disproved by the use of this instrument. Perhaps, in the future some of our specifications will be based upon the findings of the electron microscope.

[4] *News Edition*, Am. Chemical Soc., Vol. 19, September 10, 1941, p. 965.

Standard on Welding Steel for Buildings

Recently issued is the specification for design, fabrication and erection of structural steel for buildings by arc and gas welding which was prepared by the American Institute of Steel Construction's Committee on Specifications. This was set up to provide a complete specification comparable to the A.I.S.C. standard for buildings of riveted construction. There is close agreement between the tentative code of the American Welding Society and the new specification. As in the riveted specifications a number of references are made in the section on materials to A.S.T.M. specifications including A 7, A 215, and the filler metal specifications for arc welding and gas welding. Appendices give allowable stresses and recommended details, column bases and splices, beam details, and related items. Copies of this 48-page pamphlet can be obtained from the American Institute of Steel Construction, 101 Park Ave., New York, N. Y., at 25 cents per copy.

Electroplaters' National Convention

The 1942 National Convention of the American Electroplaters' Society will be held in Grand Rapids, Michigan, June 8 to 10, with the Grand Rapids branch in charge of arrangements. A number of technical sessions are planned on such subjects as organic finishing, oxide coatings and aircraft plating, electrochemical theory pertaining to electrodeposition, and electroplating.

Quite a number of A.S.T.M. members are active in the A.E.S. and the two bodies have worked closely in connection with the development of standards on electroplating.

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The "Provisional" Program

Many of us review annually the advance program, termed the Provisional Program, for our annual meeting and have usually found many items of interest. Then if we were following the usual practice, we turned to our preprint request blank, which had been received in a separate mailing, and checked those items which we would like to receive before the annual meeting. At the same time, if we could not plan to attend all of the annual meeting, we studied the Provisional Program to determine which days we would find of most interest in the technical sessions. Of course, if we were committee members the times at which our committee meetings were scheduled must definitely be considered in our annual meeting plans. Seldom did we lay much emphasis on the word "provisional" and correctly so because it would be a very unusual set of circumstances that would force shifting sessions or making such major changes. But it may be well this year to keep in mind that the program is a tentative one; and while every effort will be made to keep the final program as closely in line with the provisional one as possible, some changes may be necessary. A definite attempt will be made to advise members of major changes. There is a Circular Letter mailed to members early in June, and this should be consulted for important changes. If they develop after that date a separate communication will be necessary.

Accelerated Tests

The publication in this issue of certain discussions, one on Accelerated Testing for Packing Materials by F. C. Thorn who is responsible for much active research work in this field, the other an extensive discussion and the results of a questionnaire on accelerated testing of paints and preservative coatings should direct our thinking for a moment on methods for quickly evaluating the properties of materials. There is hardly any field where so-called accelerated tests, if such could be developed so that the results could be interpreted soundly in terms of service, would not be of extensive value. In the field of rubber products we have various tests involving the use of oxygen pressure and light sources. In the field of textiles, there are measurements for determining fastness of colors and launderability. Numerous accelerated and corrosion tests have been proposed for both ferrous and non-ferrous materials—possibly the stainless steels have come in for the most attention with many questions still remaining in the minds of numerous metallurgists as to just how valuable currently used tests may be.

Nevertheless, as materials engineers and technologists we must continually strive to develop faster and quicker tests that show reasonable results and that can be duplicated under similar conditions by any reasonably skilled technician and by results that can be interpreted to mean one thing and one only, either good or poor performance. While we are undoubtedly a long way from perfection in such tests, there is continuing emphasis and much progress has been made.

Responsibility for Emergency Provisions

Publication in the form of "pink slips" and also on other pages of this Bulletin of numerous Emergency Alternate Provisions recently approved and the publication of several complete emergency specifications which are described in a news article herein require comment on one important point—unless these emergency alternate provisions and the emergency specifications are put to use, that is, unless the provisions are invoked by the purchaser—they will definitely not achieve their principal purpose to expedite procurement or assist in the conservation of critical or strategic materials during the emergency. Indirectly the publication of these changes gives publicity to possibilities for conservation, but no amount of news mention or good will or good intentions will be effective. They must be used.

It seems that each member of the Society whether he is producing the material in question or buying or specifying it, should do all he can to bring the emergency provisions into use.

Streamlining the Annual Meeting

Included in the eighteen sessions planned for the annual meeting are some 120 technical papers and committee reports. Actually this means that more items are scheduled in several of the sessions than has been customary, but it is done in the interest of keeping to a minimum the number of sessions and the length of time members will need to be away from their offices. By a stricter enforcement of the time allotted for the presentation of reports, papers, and discussions, the schedule should be entirely practicable. Papers which have been preprinted will be allotted sufficient time to present the high lights. Technical papers not preprinted will be presented in abstract. Discussion, which represents a vital part of a technical session, will be so regulated that all who wish to discuss will be given an equal opportunity. Each discusser will be requested to stay within his alloted time. Authors of extensive written discussion will be asked to present their discussion in abstract. Every effort will be made this year to achieve our goal of conducting interesting and instructive technical sessions at which every author or discusser will be given opportunity to present his offering.

Eight New Standards Approved; Numerous Emergency Provisions

Filler Metal, Pipe Piles, Hardenability Test—Covered in "Regular" Standards; Complete Emergency Specifications on Lead Coated Hardware, Salt Spray Test on Paint, Hardness Conversion Chart; Bearing Steel

During April eight new specifications and tests were approved by Committee E-10 on Standards on the recommendation of several standing committees and also during this period emergency alternate provisions were approved in a number of important specifications.

Of the complete new standards four are of an emergency nature and are so designated in the following list which also indicates the serial designations of the three specifications and one test method approved in regular procedure:

Spec. for Hot-Dip Lead Coating on Hardware (ES-2)
Method for Conducting Salt Spray Tests on Organic Protective Coatings (ES-3)
Hardness Conversion Table for Cartridge Brass (ES-4)
Spec. for Carbon-Chromium Ball and Roller Bearing Steels (ES-5)
Spec. for Welded and Seamless Steel Pipe Piles (A 252–42 T)
Method of End-Quench Test for Hardenability of Steel (A 255–42 T)
Spec. for Iron and Steel Arc-Welding Electrodes (A 233–42 T)
Spec. for Iron and Steel Gas Welding Rods (A 251–42 T)

In order that members may have a complete list of all emergency actions taken up to May 1, there are given in the accompanying table, titles and emergency designations of the standards.

In the following article there are references to numerous emergency alternate provisions and as required by the By-laws these are given in full in the pages which follow. It will be noted from the accompanying announcement that a set of these is going to be sent to each A.S.T.M. member and a copy of the complete new specifications, whether regular or emergency, can be obtained on request without charge. Additional copies are available in accordance with the regular charge of 25 cents per copy or reduced prices on orders in quantity.

All of these changes and the new specifications have one aim, namely, the expediting of procurement and conserving critical or strategic materials during the national emergency. The committees which have taken emergency action include the following:

A-1 on Steel
A-5 on Corrosion of Iron and Steel
A-10 on Iron - Chromium - Nickel Alloys
B-1 on Copper Wires for Electrical Conductors
B-2 on Non-Ferrous Metals and Alloys
B-5 on Copper and Copper Alloys
B-6 on Die-Cast Metals and Alloys
D-1 on Paint, Varnish, Lacquer
D-11 on Rubber Products
D-12 on Soaps and Other Detergents

To make the emergency actions effective quickly, the A.S.T.M. procedure provides for approval in an appropriate subcommittee, endorsement of the chairman of the main standing committee and then approval by the Society's Committee E-10 on Standards, a reviewing committee consisting of six outstanding authorities, long-time A.S.T.M. members, who must decide whether the group has reached a substantial consensus.

Announcements of certain emergency alternate provisions were made in the March ASTM Bulletin, page 42, which article also described the first complete emergency specification issued by the Society covering lead-coated wire for electrical purposes, ES-1.

Steel

Two of the four new specifications approved in regular procedure as listed above were developed jointly with the American Welding Society, covering iron and steel arc welding electrodes and iron and steel gas welding rods. Responsibility in A.S.T.M. for these standards rests in Committee A-1 on Steel which group is also responsible for the two other new standards noted covering pipe piles and end-quench test for hardenability.

Tentative Specifications for Welded and Seamless Steel Pipe Piles.—The preliminary draft of the pipe pile standard was developed in a group of manufacturers of the material who devoted considerable time and effort in reaching a consensus, particularly on physical requirements. After detailed discussion at a meeting of a special subgroup of A.S.T.M. Subcommittee IX headed by L. H. Winkler, Bethlehem Steel Co., which included a number of design engineers and users of the material, minor substance changes and a number of editorial modifications were incorporated. The draft was finally approved by Committee A-1 and by Committee E-10 on Standards as of April 28. The requirements cover black, furnace welded, electric welded and seamless steel pipe piles and apply only to piles in which the steel tubular section acts as a permanent load-carrying member. Three grades of the material are covered, with respective minimum tensile strengths of 50,000, 60,000, 75,000 psi.; yield points, min., psi. of 30,000, 35,000, and 45,000; and elongation in 2 in. of 30, 25, and 20 per cent.

A most important part of the standard is a Table of Standard Weights and Dimensions of Welded and Seamless

New Specifications Sent on Request

Each A.S.T.M. member can obtain on request without charge a copy of the eight new standards covered in the accompanying news announcement. Emergency specifications are printed on pink paper. A set of emergency alternate provisions "pink slips" is being sent shortly to each member for affixing in the respective portions of the Book of Standards. Each slip has a page reference to the particular part of the book where it should be attached.

Steel Pipe Piles which indicates the material ranges in size (outside diameter) from $8^5/_8$ to 24 in. incl. The maximum nominal wall thickness of any of the material is $^1/_2$ in.

Proposed Tentative Method of End-Quench Test for Hardenability of Steel (A 255 – 42 T).—There has been much discussion for several years on methods for evaluating the hardenability of steel, particularly important in connection with bar-size material and related shapes, the data from which are essential in determining applications, appropriate heat treatments, etc. The literature has included a number of extensive reports and technical papers and there has been discussion at various meetings, including those of the Society of Automotive Engineers, a group which has been particularly concerned with the test. The desirability of a recognized standard has become increasingly apparent with the critical situation involving use of alternate steels. In October, 1941, the A.S.T.M.'s Executive Committee received a suggestion from a group which had been studying the so-called Jominy hardenability test that it would be extremely helpful to industry to have an A.S.T.M. standard method issued.

The matter was referred to Committee A-1 on Steel which appointed a Subcommittee on Hardenability headed by E. W. Upham, Chrysler Corp. This company had done extensive work in this field with a group which included in addition to its own metallurgists many technical men from various steel companies. In addition to their own views, members of the committee contacted by telephone and in other ways numerous interested people and concluded that the arithmetic method of plotting was most desirable at this stage and accordingly recommended it. The arithmetic chart is the one used in the Iron and Steel Institute Manual No. 5 on Possible Alternates for Nickel, Chromium and Chromium-Nickel Constructional Alloy Steels. It differs from the logarithmic chart incorporated in the methods developed in an S.A.E. subcommittee.

Hardenability is measured quantitatively usually by noting the extent or depth of hardening of a standard size and shape of test specimen in a standardized quench. In the end-quench test the "depth of hardening" is the distance along the specimen from the quenched end for a given degree of hardening. In the A.S.T.M. method the test specimen is 1 in. in diameter by 3 or 4 in. in length but optional specimens are illustrated. Requirements are given for heating, quenching, and measuring the hardness.

Filler Metal Specifications.—In its work on so-called filler metal specifications, Subcommittee XXI on Steel Welding Electrodes and Welding Rods has cooperated very closely with the Filler Metal Specifications Committee of the American Welding Society, each group being headed by J. H. Deppeler, with a number of men serving on both committees. It will be recalled that several years ago a specification was issued covering both arc and gas rods. Later, it was decided best to cover these in separate standards. In 1940 the arc welding specification was issued as A 233 – 40 T. The new arc welding specifications being issued in complete form are essentially an extended revision of the previously issued standard. A number of important modifications have been made including the introduction of yield strengths for the classes E 60 and E 70 and the addition of all the mechanical data for classes E 80, E 90, and E 100. In addition to this there are included root bend and face bend tests to determine that the electrodes can make suitable joints.

The Tentative Specifications for Iron and Steel Gas Welding Rods (A 251 – 42 T) are suitable for welding carbon and low-alloy steels. The rods are classified on the basis of tensile strength of the deposited weld metal in the stress-relieved condition. Tension test requirements vary from 50,000 min., psi. stress-relieved condition to 72,000 min., psi., in a nonstress-relieved condition for certain of the grades. Elongation in 2 in. ranges from 15 to 28 per cent. As in the arc welding specifications, there are requirements on standard sizes and lengths. Details are given on conducting the tension test, methods of packing, marking, and related requirements.

Ball and Roller Bearing Steels.—This important new emergency standard resulted from the work on National Emergency Steel Specifications under the WPB jointly sponsored by the American Iron and Steel Institute, Society of Automotive Engineers, and A.S.T.M. One of the most important Technical Advisory Committees covers Carbon and Alloy Steel Bars, Blooms, and Billets. It has several subcommittees, one of which concerns bearing steels headed by L. A. Lanning, Assistant Plant Manager, New Departure Division, General Motors Corp., the committee including leading metallurgists and technical men representing industrial consumers and general interests from the roller bearing and ball bearing fields, and steel producers. Since there was no generally applicable specification the committee devoted considerable time in cooperation with the Iron and Steel Branch, War Production Board, in drafting a standard which has been issued by A.S.T.M. in its emergency series in the interest of expediting procurement of materials, A.S.T.M. designation ES-5.

The specifications cover high-carbon chromium steel bars, rods, wire, and tubes to be used in the manufacture of ball and roller bearings. Three types of steel are specified, each having carbon range of 0.95 to 1.10, manganese 0.25 to 0.45, maximum sulfur and phosphorus, 0.025, silicon 0.20 to 0.35, maximum nickel and copper 0.25, maximum molybdenum 0.06, the chromium range being the only variable between the three types, the respective ranges for types A, B, and C, being 1.30 to 1.60, 0.90 to 1.15, and 0.40 to 0.60 per cent. Nickel, copper, and molybdenum are incidental alloying elements, and are to be reported in the heat analysis if required by the purchaser. The specification includes information on usage and detailed methods of testing, including microexamination. Decarburization and surface defects are covered with specific top limits.

It is expected this specification will be referred to the Society's Committee A-1 on Steel to consider so that it may be reviewed periodically and if revisions are necessary these can be recommended. Very probably a special section will be set up.

Emergency Alternate Provisions.—In addition to emergency provisions in four of the steel casting specifications as announced in the March BULLETIN which by consolidation of certain grades, modification of chemistry, provisions for taking the material from the furnace at higher

temperatures than now in effect, and conservation of manganese, are all in the interest of expediting procurement or conserving strategic materials, Committee A-1 has completed emergency changes in the requirements for weldable castings for service at high temperatures, A 215 and A 216, which will cover a use of material for pressure containing turbine castings which have been specified in accordance with these two standards, but which have really not been applicable until the emergency changes now cover this use.

A change in the specifications for nuts for high-temperature service A 194 provides that during the emergency bar nuts will be acceptable in place of hot-forged nuts for certain grades since forged nuts are not normally obtainable now.

To facilitate conservation of manganese, the committee as an emergency matter is deleting the manganese requirement from three of its specifications covering spring wire—hard-drawn (A 227), oil-tempered (A 229) and valve spring quality (A 230)—since the quality is amply covered by the physical requirements.

To cooperate closely with a National Emergency Steel Technical Advisory Committee on Rail and Track Accessories which is developing lists of national emergency specifications, the A.S.T.M. Steel Committee has approved changes in its Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 39) and in the Specifications for Steel for Tie Plates (A 67 – 33) and for Hot-Worked High-Carbon Steel Tie Plates (A 241 – 41), and requirements for heat-treated carbon and alloy-steel track bolts (A 183), all of which are in the interest of expediting production or conserving important materials. Requirements on alloy-steel bolts are being deleted from the specifications A 183, and the requirements for copper are being taken from the tie plate standards to conserve this element.

Details of some of these changes are published on an adjoining page; others will appear in a later BULLETIN.

Corrosion-Resisting Steels

Through action of Committee A-10 on Iron-Chromium-Nickel and Related Alloys emergency changes have been effected in the requirements for corrosion-resisting sheet, strip and plate (A 167) and corrosion-resisting material for fusion-welded pressure vessels (A 240). In the former, several of the requirements on chemical composition are being brought in line with current industrial practice and with the current scrap situation and certain modifications in the pressure vessel material also involve chemical composition so that the material can be more readily used for fabrication.

Lead Coatings on Hardware

To make available promptly standard requirements for lead-coated hardware and thus effect conservation of other metallic coating materials, A.S.T.M. Committee A-5 on Corrosion of Iron and Steel has just completed a new emergency standard carrying the designation ES-2 which gives definite requirements on weight of coating (to be not less than 30 mg. psi. of surface), continuity of coating, and related requirements. To determine the weight of coating after it is applied, a stripping test is given in the appendix to the specification, called the "glacial acetic acid test." For continuity of coating a "ferroxyl test" is specified. This specification is based on considerable research and test work carried out by the Bell Telephone Laboratories, Western Electric Co., and the Commonwealth Edison Co.

Non-Ferrous Metals and Alloys

The necessity of conserving tin, aluminum, copper, and other non-ferrous metals and the issuance of certain War Production Board orders has resulted in emergency provisions in several important specifications. In each case, the changes have been based upon the experiences of the committee members with the particular alloys or problems in question and upon their best judgment. In this field, as in some others, it may develop that experience with these emergency changes will result in the incorporation later as a regular standard.

Babbitt Metal and Solder Metal.—Of the twelve grades of white metal bearing alloys ("Babbitt Metal") covered in the A.S.T.M. Specification B 23 – 26 only six, numbers 7 through 12, could be furnished after the War Production Board ordered discontinuance of bearing metals with more than 10 per cent tin except with special permission. After Committee B-2 on Non-Ferrous Metals and Alloys had circulated its group, certain commercially available alloys with 10 per cent or less tin were set up as alternates. These are known to have been used successfully in a number of applications and in the opinion of the committee members incorporate various desirable properties. The composition of the alloys is given on the following pages, which also provide details of the appended data.

Somewhat similar action was taken on Soft Solder Metal (B 32 – 40 T) in which field the Government forbade the use of solders with more than 30 per cent tin except with special permission. Tin-lead alloys would still be applicable including the following: 30 tin to 70 lead; 25–75; 20–80; 15–85; 10–90; 5–95. The committee has suggested as an emergency provision that the alloys detailed in the provisions reprinted later in this article can be used as substitute solders.

Cartridge Brass—Hardness Conversion Relations

As a new emergency standard the Society has just issued a hardness conversion table for cartridge brass which gives relations between diamond pyramid hardness, Rockwell hardness, and Brinell hardness, the standard being designated ES-4. This work has been handled in a special section in the committee on indentation hardness of A.S.T.M. Committee E-1 on Methods of Testing, and in view of the pressing need for information on cartridge brass, it was the first material studied. Heat-treated steels are now being investigated and other materials will follow.

The hardness conversion tables for cartridge brass are the result of a series of round-robin tests conducted at the laboratories of Frankford Arsenal, American Brass Co., American Rolling Mill Co., Wilson Mechanical Instrument Co., and Bell Telephone Laboratories. A set of sixteen blocks of various tempers of cartridge brass was sent to each cooperating laboratory. These blocks were prepared by the American Brass Co. At each laboratory a minimum of five, usually ten, readings were made on each block. These test data were compared with experience data on similar material which had been collected over a

period of time at the various laboratories. These tables were published with a short report prepared by J. R. Townsend, Chairman of the committee, in the March ASTM BULLETIN, page 35.

COPPER AND COPPER ALLOYS

The work of A.S.T.M. Committee B-5 on Copper and Copper Alloys has been outstanding in the past two years to develop important standards covering widely used copper and copper alloy products and to keep existing specifications in line with industrial practice and with changes in supply of materials. The widespread use in ordnance and other related categories of products covered by Committee B-5 specifications has made the work unexcelled in importance. Three new A.S.T.M. specifications have recently been developed by this group—one covering aluminum bronze sheet and strip (B 169), another oxygen-free electrolytic copper wire bars, billets and cakes (B 170), and the third, copper-alloy condenser tube plates (B 171). These have been previously announced in the BULLETIN.

In addition to these new specifications, Committee B-5 has recently had approved as Emergency Provisions a number of modifications in several casting specifications covering the alloy—copper 88 per cent, tin 8 per cent, zinc 4 per cent (B 60); composition brass or ounce metal castings (B 62); tin-bronze and leaded tin-bronze (B 143); high-leaded tin-bronze (B 144); leaded red brass (B 145); and aluminum-bronze sand castings (B 148).

The review of the copper-base alloy castings field was made by A.S.T.M., the Federal Specifications Committee, and more recently by the S.A.E. This work was initiated at the request of the Specifications Branch of the Bureau of Industrial Conservation of the War Production Board and the development work was carried through to a successful conclusion by B-5's Subcommittee X, under the guidance of Dr. G. H. Clamer, Chairman, and Major C. H. Greenall as Chairman of the main committee.

When the work was first started, Dr. Clamer was ill and the preliminary draft of the proposal was set up by a small section under the direction of J. J. Kanter of the Crane Co. Dr. Clamer's health recovered sufficiently for him to call a meeting of Subcommittee X in Washington on March 20, 1942, at which time a full discussion of all the proposals ensued with the full cooperation of members of the Federal Specifications Committee. The recommendations of that meeting were approved by Committee E-10 on Standards on April 6.

In the meantime, a similar review of bronze casting specifications was undertaken by the Federal Specification Committee and like revisions in QQ-B-691a made.

As an illustration of the cooperative spirit between the two committees, one of the emergency alternates (Grade 3 Y) adopted by the A.S.T.M. was the Federal Grade 8 of QQ-B-691a which had not previously been covered by an A.S.T.M. specification. At the same time, the Federal Specification Committee made adjustments in impurity limits of this alloy to permit the greater use of secondary metal and to have it conform to the A.S.T.M. alternate. A new grade (No. 11) is also being added to the Federal specification which will have the same composition as the A.S.T.M. emergency alternate 5 X.

All the emergency alternates set up by A.S.T.M. have been written with two primary objects in view—first, to cut down the tin content, and secondly, to permit the greater use of secondary material. The emergency alternates to the Federal specifications also work toward exactly the same end and S.A.E. at a special meeting of their Non-ferrous Metals Division in Detroit on April 22 adopted the A.S.T.M. emergency alternates for the tin bronzes.

An illustration as to how the designer can make use of these emergency alternates can be taken directly from the emergency alternate of the Federal QQ-B-691a specification. This calls attention to four types of substitutions that may be made:

(1) Substitutions that conserve tin—a change to straight copper-zinc or to a copper silicon alloy.

(2) Substitutions that conserve both tin and copper—changing to yellow or Naval brass instead of a tin bronze.

(3) Substitutions that conserve all non-ferrous elements—changing to gray cast iron, malleable iron, or cast steel, where this is possible.

(4) When a tin bronze is absolutely necessary for the purpose in hand, to use the alloy with the lowest possible copper and tin content and to pick an emergency alternate grade that permits the use of secondary metal whenever it is possible to do so.

These are the same thoughts that should be borne in mind by any designing engineer when he examines the emergency alternate specifications to see what substitutions he can make that will result in true conservation.

A comparison of the alternate alloys being published in the usual form as pink sheets will show that chemical requirements are such as to conserve important strategic or critical alloys—in particular, tin—but in a number of cases copper also. While physical properties are lower in some cases, usually the reductions are not appreciable. In B 143 the basis of the provision is to reduce the 88-10-2 composition (copper, tin, zinc) to 88-8-4, and to further the possibility of using secondary metal, the impurity limits, particularly lead, are raised slightly. In the specifications B 144 and B 66, the emergency modifications which can be evoked call for lower tin, a greater use of zinc, and a widening of the impurity limits. The new alloy provided as an emergency in the leaded red brass specifications B 145 with nominal composition of 81 copper, 3 tin, 7 lead, and 9 zinc, about the same nominal composition as the existing alloy 5 A, has slightly higher physicals. This alloy can be used in place of many of the standards now covered except where salt or other extremely corrosive water is involved. This is the new Grade 11 which has been added to the Federal Specification. This alloy is almost identical in composition to the alternate set up in the standard B 62 and effects savings in tin and copper of about the same order.

Because of additional changes, these emergency provisions are not included in this issue, but will be issued soon as pink sheets.

DIE CASTINGS

Due to the important research work it has carried out over a period of years and the development of recognized standards of quality, the work of A.S.T.M. Committee B-6 on Die-Cast Metals and Alloys has had marked influence in stimulating the use of die castings, both the

aluminum and zinc-base types. In order to effect as much saving in aluminum as possible, emergency changes have been approved in the zinc-base specifications (B 86) by setting up alternate alloys, reducing the aluminum in one case from 3.5 to 4.5 to 1.75 to 3.50, the other chemical requirements remaining the same. The new alloys have reduced physical properties, the tensile strength for an average of five specimens being 26,000 and 30,000 psi., respectively, instead of the standard 35,000 and 40,000, and after exposure to water vapor at 95 C. for ten days—the stability test—the tensile value of 22,000 for the new alloy corresponds to 30,000 psi. for the standard. Charpy impact is 10 ft-lb. min. in one new alloy compared with 12 min. in the standard, and in the other new alloy which is an alternate for the existing No. XXV, the value of 2.0 ft-lb. min. applies instead of 6.0

In the aluminum-base specification (B 85), alloy No. VII, a 4 per cent copper, 5 silicon, 91 aluminum composition, has been set up as an alternate alloy with a lower iron content. This is suitable for casting by the cold process method. It will be noted that the maximum permissible iron has been decreased from the present 2.3 to 1.3 per cent.

Paint Materials

Increasing use of salt spray tests on organic protective coatings for specified properties has led A.S.T.M. Committee D-1 on Paint, Varnish, Lacquer, and Related Products to agree as an emergency matter on a standard procedure similar to the method already issued by another A.S.T.M. committee in the non-ferrous field—Salt Spray Testing of Non-Ferrous Metals (B 117 – 41 T). A note is to appear indicating that the salt spray test is not intended for use as a means for determining the general durability or weather resistance of organic protective coatings for metals. Its use is suggested as a convenient means of estimating the protection against corrosion afforded by a given paint coating or system where saline conditions may be encountered. Another note indicates that if the results obtained in various laboratories are to be strictly comparable, it is essential that all laboratories using this method should use identical solutions. It is suggested that the 20 per cent solution be adopted where the method is to be used for testing organic protective coatings on metal. This emergency standard will carry the designation ES-3.

An emergency alternate provision in the specification for white lead was announced in the March Bulletin by which the lead oxide coating of 15.0 to 28.0 per cent is being altered to provide a 11.0 to 28.0 per cent range, thus increasing available products about 25 per cent.

Rubber Insulated Wire and Cable

The second of a number of emergency changes developed by A.S.T.M. Committee D-11 on Rubber Products has been made in the requirements for insulated wire and cable: class AO, 30 per cent Hevea rubber compound (D 27) which provides that the conductor can be coated with tin, lead, or lead-alloy, and then reference is made to the new emergency specifications for lead-alloy coated copper wire ES-1, which gives tests for continuity and related properties. A number of the emergency modifications relate to the cable cotton tape, one of which provides that instead of being frictioned on both sides and thoroughly filled with a rubber compound, it "shall be treated on one side with an insulating compound of a nature not injurious to the wire insulation." Since these specifications are referred to in three other standards for insulated wire performance rubber compound (D 353), heat-resisting rubber compound (D 469), and ozone-resistant type insulation (D 574), the changes also affect these specifications.

In the specifications for insulated wire and cable (D 353) important physical test requirements have been modified reducing the tensile strength from 1200 to 850 min. psi.; elongation at rupture, 300, instead of 400 per cent; and a marked reduction in the tensile strength after 48 hr. in the oxygen pressure test to 600 psi. min. Other physical requirements are being deleted for the emergency.

Correspondingly in the requirements for rubber sheath compound (D 532) tensile strength is being reduced from 3500 to 3000 psi. min.; elongation at rupture from 500 to 400; requirements on tear resistance and tensile strength at 200 per cent elongation are being deleted.

The committee also considered modifications in the specifications for cotton rubber-lined fire hose (D 296) and after further study in the subcommittee it is expected emergency changes will be approved.

Soaps and Other Detergents

One of the most active A.S.T.M. committees in the development of standard specifications and tests has been Committee D-12 on Soaps and Other Detergents. Many of the products covered in its specifications have been affected by rulings of the Government in connection with glycerol content, fat stock, and so forth. To effect saving of critical materials Committee D-12 has approved a number of emergency changes. As an example, in the requirements for white floating toilet soap (D 499 – 39) the word "white" is to be deleted wherever it occurs and the requirement which normally does not permit any rosin, sugar, and foreign matter is to be revised to permit maximum rosin of 10 per cent. Changes are being made in Specifications for Milled Toilet Soap (D 455 – 39) and Specifications for Built Soap, Powdered (D 533 – 41).

In connection with certain materials as for salt-water soap (D 593 – 40 T), since no substitute is available at present, the various producers of this soap have signified their willingness to endeavor to make up products which might be suitable for use in salt water. If these new products prove acceptable, Committee D-12 on Soaps and Other Detergents will prepare specifications based on the product or products found to be most suitable for this use.

Two specifications cover soaps containing olive oil—Chip Soap (D 630 – 41 T) and Solid Soap (D 592 – 41 T). The references to olive oil are to be eliminated. As an emergency matter the manufacturer can substitute any oil that will produce a soap conforming to the chemical analysis prescribed in the chip soap. The titer requirement of the mixed fatty acids for type A which is the powdered material is being changed from the present range of 16 to 26 C. to read 26 C. maximum. A similar change is incorporated in D 592. In both specifications the other chemical requirements are remaining unchanged. These cover moisture and volatile matter, free alkali, matter insoluble in water, iodine number, anhydrous soap content, and related quality factors.

List of Emergency Alternate Provisions—Issued as of April 28, 1942

Emergency Alternate Designation	Title
	Specifications for:
EA – A 1	Open-Hearth Carbon-Steel Rails
EA – A 26	Steel Tires
EA – A 27	Carbon-Steel Castings for Miscellaneous Industrial Uses
EA – A 67	Steel Tie Plates
EA – A 87	Carbon-Steel and Alloy-Steel Castings for Railroads
EA – A 148	Alloy-Steel Castings for Structural Purposes
EA – A 160	Axle-Steel Bars for Concrete Reinforcement
EA – A 167	Corrosion-Resisting Chromium-Nickel Steel Sheet, Strip, and Plate
EA – A 183	Heat-Treated Carbon- and Alloy-Steel Track Bolts and Nuts
EA – A 194	Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service to 1100 F.
EA – A 215	Carbon-Steel Castings Suitable for Fusion Welding for Miscellaneous Industrial Uses
EA – A 216	Carbon-Steel Castings Suitable for Fusion Welding for Service at Temperatures up to 850 F.
EA – A 217	Alloy-Steel Castings Suitable for Fusion Welding for Service at Temperatures from 750 to 1100 F.
EA – A 227	Hard-Drawn Steel Spring Wire
EA – A 229	Oil-Tempered Steel Spring Wire
EA – A 230	Carbon-Steel Valve Spring Quality Wire
EA – A 240	Corrosion-Resisting Chromium-Nickel Steel Sheet, Strip, and Plate for Fusion-Welded Unfired Pressure Vessels
EA – A 241	Hot-Worked High-Carbon Steel Tie Plates
EA – B 23	White Metal Bearing Alloys (Known Commercially as "Babbitt Metal")
EA – B 32	Soft Solid Metal
EA – B 30	Copper-Base Alloys in Ingot Form for Sand Castings

Emergency Alternate Designation	Title
EA – B 60	Castings of the Alloy: Copper 88 per cent, Tin 8 per cent, Zinc 4 per cent
EA – B 62	Composition Brass or Ounce Metal Castings
EA – B 85	Aluminum-Base Alloy Die Castings
EA – B 86	Zinc-Base Alloy Die Castings
EA – B 143	Tin-Bronze and Leaded Tin-Bronze Sand Castings
EA – B 144	High-Leaded Tin-Bronze Sand Castings
EA – B 145	Leaded Red Brass and Leaded Semi Red Brass
EA – B 148	Aluminum-Bronze Sand Castings
EA – B 158	Rope-Lay-Stranded and Bunch-Stranded Copper Cables for Electrical Conductors
EA – D 27	Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound
EA – D 82	Basic Sulfate White Lead
EA – D 353	Insulated Wire and Cable: Performance Rubber Compound
EA – D 455	Milled Toilet Soap
EA – D 469	Insulated Wire and Cable: Heat-Resisting Rubber Compound
EA – D 499	White Floating Toilet Soap
EA – D 532	Rubber Sheath Compound for Electrical Insulated Cords and Cables
EA – D 533	Built Soap, Powdered
EA – D 535	Palm Oil Solid Soap (Type A, Pure; Type B, Blended)
EA – D 536	Palm Oil Chip Soap (Type A, Pure; Type B, Blended)
EA – D 574	Insulated Wire and Cable: Ozone-Resistant Type Insulation
EA – D 592	Olive Oil Solid Soap (Type A, Pure; Type B, Blended)
EA – D 593	Salt-Water Soap
EA – D 630	Olive Oil Chip Soap (Type A, Pure; Type B, Blended)

EA – A 26
Issued, April 28, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Steel Tires (A 26 – 39) and affects only the requirements referred to:

Section 4.—Change the requirements for chemical composition to read as follows:

Carbon, per cent	Class A	0.50 to 0.65
	Class B	0.60 to 0.75
	Class C	0.70 to 0.85
Manganese, per cent		0.50 to 0.75
Phosphorus, max., per cent		0.05
Sulfur, max., per cent	basic steel	0.05
	acid steel	0.06
Silicon, per cent		0.15 to 0.35

EA – A 194
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Carbon and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service to 1100 F. (A 194 – 40) and affects only the requirement referred to:

Section 1.—Add the following note to this section:

NOTE.—In the event that forged nuts in sizes 1/2 in. and under are unobtainable, bar nuts will be acceptable.

EA – A 216
Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Carbon-Steel Castings Suitable for Fusion Welding for Service at Temperatures up to 850 F. (A 216 – 41 T) and affect only the requirements referred to:

Section 1 (b).—Add two new grades of carbon-steel castings suitable for welding for applications as pressure containing turbine castings, as follows:

Grade EWCC—Grade EWCD

Section 3.—Add to Paragraph (*a*) the following requirements as to chemical composition for Grades EWCC and EWCD.

Grades:	EWCC	EWCD
Carbon, max., per cent	0.30[a]	0.35[a]
Manganese, max., per cent	0.60[a]	0.70[a]
Phosphorus, max., per cent	0.05	0.05
Sulfur, max., per cent	0.06	0.06
Silicon, max., per cent	0.60	0.60

[a] For each reduction of 0.01 per cent below the specified maximum carbon content, an increase of 0.04 per cent manganese above the specified maximum will be permitted up to a maximum of 1.00 per cent.

Add in Paragraph (*b*) the symbols "EWCC" and "EWCD" to the heading of the table, since the requirements of this section apply to the two new grades.

Section 8 (a).—Add the following requirements for grades EWCC and EWCD:

Grades:	EWCC	EWCD
Tensile strength, min., psi	60 000	65 000
Yield point, min., psi	30 000	35 000
Elongation in 2 in., min., per cent	24	20
Reduction of area, min., per cent	35	30

Section 10 (a).—Add the symbols "EWCC" and "EWCD," since the requirements of this section apply to the two new grades.

Section 16 (a).—Add the symbols "EWCC" and "EWCD", since the requirements of this section apply to the two new grades.

EA – A 217
Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Alloy-Steel Castings Suitable for Fusion Welding at Temperatures from 750 to 1100 F. (A 217 – 41 T) and affect only the requirements referred to:

Section 1 (b).—Add one new grade of alloy-steel castings suitable for welding for pressure containing turbine castings, as follows:

Grade EWC5

Section 5.—Add to Paragraph (*a*) the following requirements as to chemical composition for Grade EWC5:

	Grade EWC5
Carbon, max., per cent	0.30[a]
Manganese, max., per cent	0.70[a]
Phosphorus, max., per cent	0.05
Sulfur, max., per cent	0.06
Silicon, max., per cent	0.60
Nickel, per cent	....
Chromium, per cent	....
Molybdenum, per cent	0.40 to 0.60

[a] For each reduction of 0.01 per cent below the specified maximum carbon content, an increase of 0.04 per cent manganese above the specified maximum will be permitted up to a maximum of 1.00 per cent.

Add to Paragraph (*b*) the following requirements for grade EWC5:

	Grade EWC5
Copper, max., per cent	0.50
Nickel, max., per cent	0.50
Chromium, max., per cent	0.25
Tungsten, max., per cent	0.10
Total content of these unspecified elements, max., per cent	1.0

Section 8 (a).—Add the following requirements for grade EWC5:

	Grade EWC5
Tensile strength, min., psi	65 000
Yield point, min., psi	35 000
Elongation in 2 in., min., per cent	20
Reduction of area, min., per cent	30

Section 17 (a).—Add the symbol "EWC5," since the requirements of this section apply to the new grade.

EA – A 227
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Hard-Drawn Steel Spring Wire (A 227 – 41) and affects only the requirement referred to:

Section 4.—Omit the requirement for manganese, which reads as follows:

Manganese, per cent .... 0.60 to 1.20[b]

[b] Manganese in any one lot shall not vary more than 0.30 per cent.

EA – A 229
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Oil-Tempered Steel Spring Wire (A 229 – 41) and affects only the requirements referred to:

Section 4.—Omit the requirements for manganese in compositions A and B, which read as follows:

	Composition A	Composition B
Manganese, per cent	0.80 to 1.20	0.60 to 0.90

EA – A 230
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Carbon-Steel Valve Spring Quality Wire (A 230 – 41) and affects only the requirement referred to:

Section 4.—Omit the requirement for manganese, which reads as follows:

Manganese, per cent .... 0.50 to 0.80

Footnote a.—Omit the reference to manganese in this footnote.

EA – B 23
Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for White Metal Bearing Alloys (Known Commercially as "Babbitt Metal") (B 23 – 26) and affect only the requirements referred to:

Section 4 and Table I.—Due to the fact that the Government has forbidden the use of White Metal Bearing Alloys containing more than 12 per cent tin (except by special permission of appropriate Government board) the following alternate alloys, commercially available, may be employed:

TABLE I.—CHEMICAL REQUIREMENTS.[a]

Alloy Grade	Tin, per cent	Antimony, per cent	Lead	Copper, per cent	Silver, per cent	Arsenic, per cent
No. 13.	2.0	15	remainder	0.25 max.	2.5	....
No. 14.	0.75	12.75	remainder	....	...	1.5 to 3.0
No. 15.	0.9 to 1.25	14.75 to 15.5	remainder	0.4 to 0.6	...	0.6 to 1.1
No. 16.	10	12.5	remainder	0.4 to 0.6	...	....
No. 17.	6	10	remainder	0.25 max.	...	....
No. 18.	1.0	17	remainder	0.4 to 0.6	...	0.8 to 1.4

[a] Where tolerances or limits are not prescribed in this table, the permissible variations specified in Section 5 of Standard B 23 – 26 apply.

Appendix.—Add the following data as information to the table of physical properties of white metal bearing alloys which appears in the Appendix of Standard V 23 – 26:

PHYSICAL PROPERTIES OF ALTERNATE ALLOYS.

Alloy Grade	Brinell Hardness		Melting Ranges				Pouring Temperature	
			Solidus		Liquidus			
	At 20 C.	At 100 C.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.
No. 13..	..	..	...	...	...	...	...	...
No. 14..	22	15	469	243	563	295	689	365
No. 15..	21	13	...	...	...	...	...	...
No. 16..	27.5	13.6	471	244	495	257	621	327
No. 17..	20	11	...	...	...	...	...	...
No. 18..	29	16	...	...	...	...	875	468

EA – B 32
Issued April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Soft Solder Metal (B 32 – 40 T) and affect only the requirements referred to:

Section 3.—Due to the fact that the Government has forbidden the use of solders containing more than 30 per cent tin (except by special permission of appropriate Government board) typical tin-lead alloy compositions follow:

Tin, per cent	Lead, per cent
30	70
25	75
20	80
15	85
10	90
5	95

In addition to the above tin-lead alloys the following alloys are suggested as substitute solders:

Alloy	Tin,[a] per cent	Lead, per cent	Bismuth,[a] per cent	Silver,[a] per cent	Antimony, per cent	Copper, per cent
1..	25	remainder	0.5	0.5	0.5 max.	......
2..	20	remainder	15	none	......	......
3..	20	remainder	10	none	......	......
4..	20	remainder	3	1.5	......	......
5..	15	remainder	5	1.5	0.5 max.	0.5 max.
6..	10	remainder	5	2	0.5 max.	......
7..	0.65 to 0.85	remainder	none	0.25	......	......
8..	none	remainder	none	1 to 5	......	0.5 max.

[a] The permissible variations in these elements shall be as follows: Tin: nominal −0.50, except in the case of alloys 7 and 8; Bismuth: plus or minus 0.25; Silver: plus or minus 0.10.

The above listed typical tin-lead alloy compositions and the eight alternate alloys are hand and dipping solders and cannot be used for wiping.

Appendix.—Add the following data as information to the table of properties of soft solder metal which appears in the Appendix of Specifications B 32 – 40 T; the figures for the first six alloys replacing the data for the corresponding alloys now appearing in the Appendix:

PROPERTIES OF SOFT SOLDER METAL.

Nominal Composition, per cent				Melting Range			
				Solidus		Liquidus	
Tin	Lead	Bismuth	Silver	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.
30	70	..	..	361	183	486	252
25	75	..	..	361	183	509	265
20	80	..	..	361	183	523	273
15	85	..	..	437	225	543	284
10	90	..	..	527	275	567	297
5	95	..	..	576	302	592	311
25	remainder	0.5	0.5	..	..	..	..
20	65	15	none	338[c]	170[c]	422[c]	216[c]
20	70	10	none	396[c]	202[c]	460[c]	238[c]
20	remainder	3	1.5	419[c]	215[c]	496[c]	258[c]
15	remainder	5	1.5[a]	419[c]	215[c]	496[c]	258[c]
10	remainder	5	2	419[c]	215[c]	529[c]	276[c]
0.75	remainder	none	0.25	605[c]	318[c]	615[c]	324[c]
none	95	none	5	579	304	715	380
none	96	none	4	579	304	653	345
none	97.5	none	2.5	579	304	579	304
none	98	none	2	579	304	590	310
none	99	none	1	579	304	604	318
none	97.25[b]	none	2.5	576[c]	302[c]	590[c]	310[c]

[a] Also antimony 0.5 per cent, max.
[b] Also copper 0.25 per cent, max.
[c] Estimated by pyrometer and visual appearance.

EA – B 85
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85 – 39 T) and affects only the requirements referred to:

Table I.—Add the following requirements for alloy No. VII-B as a substitute for the present alloy No. VII:

	Alloy No. VII-B
Copper, per cent	3.5 to 4.5
Silicon, per cent	4.5 to 5.5
Nickel, max., per cent	0.3
Iron, max., per cent	1.3
Zinc, max., per cent	1.0
Manganese, max., per cent	0.5
Magnesium, max., per cent	0.10
Tin, max., per cent	0.15
Chromium, max., per cent	0.2
Total other impurities, max., per cent	0.3
Aluminum, per cent	remainder

EA – B 86
Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 41 T) and affect only the requirements referred to:

Table I.—Add the following requirements as to chemical composition for alloys Nos. XXIV and XXVI as alternates for alloys Nos. XXIII and XXV, respectively:

	Alloy No. XXIV[a]	Alloy No. XXVI[a]
Copper, per cent	0.10 max.	0.75 to 1.25
Aluminum, per cent	1.75 to 3.50	1.50 to 3.50
Magnesium, per cent	0.03 to 0.08	0.03 to 0.08
Iron, max., per cent	0.100	0.100
Lead, max., per cent	0.007	0.007
Cadmium, max., per cent	0.005	0.005
Tin, max., per cent	0.005	0.005
Zinc, per cent	remainder	remainder

[a] Alloys Nos. XXIV and XXVI are modifications of Alloys Nos. XXIII and XXV, respectively, and their use is intended to conserve aluminum during the war emergency. They are *not* intended for those applications where failure would result in personal or industrial hazard.

Table II.—Add the following requirements as to physical properties for alloys Nos. XXIV and XXVI:

	Average of Specimens Tested (See Section 10)		Individual Specimens	
	Alloy No. XXIV	Alloy No. XXVI	Alloy No. XXIV	Alloy No. XXVI
Tensile strength, min., psi.	26 000	30 000	23 000	24 000
Elongation in 2 in., min., per cent	3.0	2.0	2.0	0.5
Charpy impact, min., ft-lb.	12.0	12.0	8.0	8.0

Section 7.—Add the following requirements as to physical properties for Alloys Nos. XXIV and XXVI after 10-day exposure to water vapor at 95 C.:

	Average of Specimens Tested (See Section 10)	
	Alloy No. XXIV	Alloy No. XXVI
Tensile strength, min., psi	22 000	22 000
Elongation in 2 in., min., per cent	1.5	1.0
Charpy impact, min., ft-lb	10.0	2.0

Section 8 (a).—For these two alternate alloys add the following requirements for the average expansion of any five or more castings or test specimens after being exposed to water vapor at 95 C. for ten days:

Alloy	Expansion per Inch, max., in.
No. XXIV	0.0015
No. XXVI	0.0015

EA – D 27
Issued, April 6, 1942
(Superseding Issue of August 25, 1941)

The following Emergency Alternate Provisions, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (D 27 – 41) and affects only the requirements referred to:

Section 2.—Change this section to read as follows:

2. The conductor shall be soft annealed copper properly coated with tin, lead, or lead-alloy, and shall have the properties and characteristics specified in Sections 3 to 7. Coatings conducive to galvanic action at splices, such as zinc, are not recommended.

Section 7 (a).—Change the heading of this section to read "Continuity of Coating Test," and add a new sentence at the end to read as follows:

Where lead or lead-alloy coated wire is used the continuity of the lead coating shall be determined in accordance with Section 7 of the Emergency Specifications for Lead-Coated and Lead-Alloy-Coated Copper Wire for Electrical Purposes (A.S.T.M. Designation: ES – 1) of the American Society for Testing Materials.

Section 7 (b).—Change to read as follows:

(*b*) Retests and Rejections.—If the specimens tested in accordance with Paragraph (*a*) show any signs of failure, two more specimens shall be tested. If one of these two additional specimens fail, that coil or reel shall be rejected. If both specimens pass the test for continuity of coating, the coil or reel shall be accepted. If more than 10 per cent of the samples in the entire order fail, all of the wire shall be rejected. If 10 per cent or less of the samples in the entire lot fail, each coil, reel, or length may be tested and accepted or rejected upon the results of the individual tests.

Section 25.—Change to read as follows:

25. Cable tape made from cotton cloth of the following constructions may be used:

	Weight, lb. per sq. yd.	Number of Yards per Pound (40-in. Width)	Thread Count
Alternate (a)	0.225	4.00	60 by 52
Alternate (b)	0.210	4.30	56 by 48

The tape shall be treated on one side with an insulating compound of a nature not injurious to the wire insulation. The nominal thickness shall be 0.012 in. and not less than 0.011 in. Other types of tape may be used if approved by the purchaser.

Section 28.—Change "standard braid" to read "code braid."

Section 29.—In the heading and in this section change "standard braid" to read "code braid."

Section 30.—Change to read as follows:

30\. Cotton braids shall be closely woven from cotton yarn. Single ply yarn may be used if the diameter under the braid is 0.8 in. or less. For diameters greater than 0.8 in. and for heavy braids at least two ply yarn shall be used.

Section 31 (b).—Change "standard braid" to read "code braid."

Table VII.—Change to read as follows:

TABLE VII.—MINIMUM THICKNESS OF CODE BRAID

Diameter Under Braid, in.	Minimum Thickness of Braid, in.
0 to 0.200	0.015
0.201 to 0.350	0.017
0.351 to 0.800	0.020
0.801 to 1.500	0.025
1.501 to 3.000	0.031

Section 31 (c).—Change the values for the closeness constant "X" to read as follows:

Diameter Under Braid, in.	Values of X	
	Code Braids	Heavy Braids
0 to 0.500	1.7	1.1
0.501 and over	1.5	1.0

Table IX.—Designate the values of Y in the present Table IX as applying to heavy braids and add to this table the values for Y applying to code braids as given in the accompanying Table IXa.

TABLE IXa.—VALUES OF Y FOR CODE BRAIDS.

Size and Ply of Cotton Yarn	Thickness of Braid, T	Values of Y: For Diameters Under 0.500 in.				For Diameters 0.501 in. and Over				
		2 Ends	3 Ends	4 Ends	5 Ends	2 Ends	3 Ends	4 Ends	5 Ends	6 Ends
14/1	0.015	755	453	...	...	...	...	...	...	..
12/1	0.0161	699	406	...	...	...	...	...	...	..
10/1	0.0176	625	351	212	136	...	...	...	...	..
8/1	0.0197	541	290	170	107	603	325	191	120	..
30/2	0.0162	693	397	246	161	...	...	...	...	..
28/2	0.0168	662	377	230	149	...	...	...	...	..
26/2	0.0175	631	355	215	138	...	...	...	...	..
24/2	0.0182	601	333	199	127	...	...	...	...	..
22/2	0.0190	568	310	183	115	...	...	...	...	..
20/2	0.0200	528	284	166	103	603	318	186	116	77
18/2	0.0210	497	260	150	92	563	292	168	103	68
16/2	0.0223	452	232	133	81	516	262	149	91	59
14/2	0.0238	412	207	115	69	465	232	129	78	50
12/2	0.0257	367	176	97	57	411	199	109	65	41
10/2	0.0292	316	148	79	46	355	166	88	52	32
8/2	0.0316	262	108	60	34	292	130	68	39	24
16/3	0.0278	322	152	81	47	362	170	91	53	33
14/3	0.0298	288	132	69	40	324	148	78	45	28
12/3	0.0322	252	112	57	32	282	126	65	37	22
10/3	0.0352	212	91	46	25	238	103	52	29	17
8/3	0.0394	171	70	34	18	191	79	39	21	13

Table X.—Omit from Table X the typical construction requirements for standard braid and add to this table the typical construction requirements for code braid as given in the accompanying Table Xa.

TABLE Xa.—TYPICAL CONSTRUCTIONS FOR CODE BRAID.

Size of Class R, 600-v. Conductors, A.w.g. numbers or cir. mils.	Nominal Diameter Over Insulation, in.	Carriers	Picks per Inch: Size and Ply	14/1		30/2		26/2 and 12/1		24/2		20/2 and 10/1			16/2			12/2			10/2		8/2	
			Ends	2	3	2	3	2	3	2	3	2	3	4	2	3	4	2	3	4	3	4	3	4
No. 14 Solid		16		23.4	15.8	22.2	13.9	20.8	12.5	20.1	11.6	18.5	...	...	...	...	...	...	...	...	...	...	...	...
No. 14 Stranded	0.151 to 0.175	20		20.8	12.5	19.4	12.4	17.8	...	17.0	...	15.0	...	...	...	...	...	...	...	...	...	...	...	...
No. 12 Solid		16		24.4	17.2	23.2	15.5	21.8	14.1	21.2	13.4	19.5	11.6	...	...	...	...	...	...	...	...	...	...	...
		20		22.5	14.4	21.2	12.4	19.7	...	19.3	...	17.2	...	...	...	...	...	...	...	...	...	...	...	...
No. 12 Stranded	0.176 to 0.200	24		20.1	...	18.5	...	16.8	...	16.1	...	13.8	...	...	...	...	...	...	...	...	...	...	...	...
No. 10 Solid		16		...	...	...	...	22.5	15.2	21.9	14.5	20.2	12.8	...	...	...	...	...	...	...	...	...	...	...
		20		...	...	...	...	21.0	12.8	20.3	12.0	18.5	9.9	...	...	...	...	...	...	...	...	...	...	...
	0.201 to 0.225	24		...	...	...	...	18.9	...	18.1	...	16.1	...	...	...	...	...	...	...	...	...	...	...	...
No. 10 Stranded		16		...	...	...	...	23.1	16.0	22.4	15.3	20.7	13.7	...	...	...	...	...	...	...	...	...	...	...
		20		...	...	...	...	21.8	14.2	21.2	13.4	19.4	11.5	...	...	...	...	...	...	...	...	...	...	...
	0.226 to 0.250	24		...	...	...	...	20.2	11.4	19.4	10.5	17.6	...	...	...	...	...	...	...	...	...	...	...	...
		16		...	...	...	...	23.6	16.7	23.1	16.0	21.3	14.5	...	19.4	12.6	...	...	...	...	...	...	...	...
		20		...	...	...	...	22.6	15.4	22.0	14.7	20.3	13.0	...	18.4	10.9	...	...	...	...	...	...	...	...
No. 8 Solid, No. 8 Stranded	0.251 to 0.300	24		...	...	...	...	21.5	13.6	20.8	12.8	19.0	10.8	...	17.0	...	...	...	...	...	...	...	...	...
		16		...	...	...	...	24.0	17.3	23.4	16.7	21.7	15.1	...	20.0	13.3	...	...	...	...	...	...	...	...
		20		...	...	...	...	23.4	16.4	22.7	15.7	21.0	14.1	...	19.2	12.2	...	...	...	...	...	...	...	...
No. 6	0.301 to 0.360	24		...	...	...	...	22.5	15.2	21.9	14.5	20.2	12.7	...	18.2	10.5	...	...	...	...	...	...	...	...
No. 5		16		...	...	...	...	...	...	...	...	22.1	15.6	...	20.3	13.7	...	18.0	11.5	...	...	...	...	...
		20		...	...	...	...	...	...	...	...	21.5	14.8	...	19.7	12.9	...	17.7	10.6	...	...	...	...	...
No. 4	0.361 to 0.400	24		...	...	...	...	...	...	...	...	20.8	13.8	...	18.9	11.8	...	16.9	9.3	...	...	...	...	...
No. 3		16		...	...	...	...	...	...	...	...	22.4	15.9	...	20.5	14.1	...	18.2	12.0	...	...	...	...	...
		20		...	...	...	...	...	...	...	...	21.8	15.2	...	20.0	13.5	...	18.1	11.2	...	...	...	...	...
No. 2	0.401 to 0.450	24		...	...	...	...	...	...	...	...	21.3	14.5	...	19.5	12.6	...	17.4	10.2	...	...	...	...	...
		16		...	...	...	...	...	...	...	...	22.6	16.2	...	20.7	14.4	...	18.4	12.3	...	...	...	...	...
		20		...	...	...	...	...	...	...	...	22.1	15.6	...	20.3	13.8	...	18.3	11.6	...	...	...	...	...
No. 1	0.451 to 0.500	24		...	...	...	...	...	...	...	...	21.6	15.0	...	19.8	13.2	...	17.9	10.8	...	...	...	...	...
		20		...	...	...	...	...	...	...	...	...	16.9	12.4	...	15.2	11.9	...	13.0	8.9	...	...	...	...
No. 0	0.501 to 0.600	24		...	...	...	...	...	...	...	...	...	16.5	11.9	...	14.7	10.2	...	12.4	8.1	...	...	...	...
No. 00		20		...	...	...	...	...	...	...	...	...	17.3	12.9	...	15.6	11.4	...	13.4	9.5	12.1	8.3	...	...
No. 000 to 250 000		24		...	...	...	...	...	...	...	...	...	17.0	12.5	...	15.3	11.0	...	13.1	9.1	11.8	7.8	...	...
cir. mils	0.601 to 0.800	20		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13.7	9.9	12.4	8.7	10.9	7.5
300 000 to 450 000		24		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13.5	9.6	12.2	8.4	10.6	7.2
cir. mils	0.801 to 1.000	24		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13.7	9.9	12.5	8.7	10.9	7.6
500 000 to 700 000		36		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13.1	9.1	12.0	7.9	10.2	6.8
cir. mils	1.001 to 1.200	48		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12.4	7.9	11.0	6.5	9.7	...
		24		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13.8	10.1	12.6	8.9	11.0	7.8
750 000 to 1 000 000		36		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13.5	9.6	12.2	8.5	10.6	7.5
cir. mils	1.201 to 1.500	48		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13.0	8.9	11.6	7.5	10.0	6.1
		24		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11.2	8.0
		36		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11.0	7.6
1 230 000 to 2 000	1.501 to 2.000	48		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10.7	7.1
000 cir. mils		24		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8.1
		36		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8.0
	2.001 to 3.000	48		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7.7

EA – D 353
Issued, April 6, 1962

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Insulated Wire and Cable: Performance Rubber Compound (D 353 – 41) and affect only the requirements referred to:

Section 1 (b).—Change to read as follows by the addition of the italicized words and figures:

(*b*) Except for the rubber insulation, wire and cable supplied under these specifications shall conform to the Standard Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (A.S.T.M. Designation: D 27), *modified in accordance with the Emergency Alternate Provisions EA – D 27*, of the American Society for Testing Materials.

Table 1.—Replace the present Table I by the following requirements or physical tests of the insulation:

TABLE I.—PHYSICAL TEST REQUIREMENTS FOR INSULATION.

Tensile strength, min., psi	850
Elongation at rupture, min., per cent	300
Set in 2-in. gage length, max., in	0.5
Tensile strength after 48 hr. in oxygen pressure test, min., psi.	600

Table III.—Reduce the tabulated values in Table III for insulation resistance by 50 per cent.

In Note 1 under Table III change the constant "K = 21,120" to read "K = 10,560."

EA – D 455
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Milled Toilet Soap (D 455 – 39) and affects only the requirement referred to:

Section 3.—In the table of chemical composition requirements, change the requirement for rosin, sugar, and foreign matter from:

Rosin, sugar, and foreign matter	none

to read as follows:

Rosin, max., per cent based on finished product	10
Sugar and foreign matter	none

EA – D 469
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Insulated Wire and Cable: Heat-Resisting Rubber Compound (D 469 – 41) and affects only the requirements referred to:

Section 1 (b).—Change to read as follows by the addition of the italicized words and figures:

(*b*) Except for the rubber insulation, wire and cable supplied under these specifications shall conform to the Standard Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (A.S.T.M. Designation: D 27), *modified in accordance with the Emergency Alternate Provisions EA – D 27*, of the American Society for Testing Materials.

EA – D 499
Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for White Floating Toilet Soap (D 499 – 39) and affect only the requirements referred to:

Title and Text.—Omit the word "White" wherever it occurs in these specifications.

Section 3.—In the table of chemical composition requirements, change the requirement for rosin, sugar, and foreign matter from:

Rosin, sugar, and foreign matter	none

to read as follows:

Rosin, max., per cent based on finished product	10
Sugar and foreign matter	none

Omit the requirement for acid number which reads as follows:

Acid number of the mixed fatty acids prepared from the soap, min	212

EA – D 532
Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Rubber Sheath Compound for Electrical Insulated Cords and Cables (D 532 – 39 T) and affect only the requirements referred to:

Section 3.—Omit the present table of requirements and substitute the following requirements for physical tests of the vulcanized rubber sheath:

Tensile strength, min., psi	3000
Elongation at rupture, min., per cent	400
Set in 2-in. gage length, max., in	0.25
Tensile strength after 48 hr. in oxygen pressure test, min., psi	2500

Section 6 (a).—Omit the phrase "with the exception of the tear test" from the beginning of the second sentence.

Section 6 (b).—Omit this paragraph which describes the tear test specimen.

Fig. 1.—Omit this figure which shows the test specimen for the tear test.

Section 8.—Omit this section which describes the tear test.

EA – D 533
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Standard Specifications for Built Soap, Powdered (D 533 – 41) and affects only the requirements referred to:

Table I.—Add the following requirements for type D built soap as an alternate for present types A, B, and C:

	Type D
Moisture and matter volatile at 105 C., max., per cent	16.0[a]
Sum of free alkali and total matter insoluble in alcohol (alkaline salts), max., per cent	40.0
Matter insoluble in water, max., per cent	1.0
Material passing an 105-micron (No. 140) sieve, max., per cent	20.0
Material retained on a 1680-micron (No. 12) sieve, max., per cent	1.5
Rosin acids, max., per cent based on the finished product	10.0
Anhydrous soap content, min., per cent	50.0

[a] Deliveries which yield more than 16 per cent volatile matter shall be rejected without further test.

EA – D 535
Issued, April 6, 1942

As an Emergency Alternate Provision, when specified, soap conforming to the Standard Specifications for Chip Soap (A.S.T.M. Designation: D 496) of the American Society for Testing Materials, may be furnished in place of palm oil solid soap.

EA – D 536
Issued, April 6, 1942

As an Emergency Alternate Provision, when specified, soap conforming to the Standard Specifications for Chip Soap (A.S.T.M. Designation: D 496) of the American Society for Testing Materials, may be furnished in place of palm oil chip soap.

EA – D 574
Issued, April 6, 1942

The following Emergency Alternate Provision, when specified, may be used as an alternate in A.S.T.M. Tentative Specifications for Insulated Wire and Cable: Ozone-Resistant Type Insulation (D 574 – 40 T) and affects only the requirements referred to:

Section 1 (b).—Change to read as follows by the addition of the italicized words and figures:

(*b*) Except for the insulation, cable supplied under these specifications, unless otherwise specified by the purchaser, shall conform to the Standard Specifications for Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound (A.S.T.M. Designation: D 27), *modified in accordance with the Emergency Alternate Provisions EA – D 27*, of the American Society for Testing Materials.

EA - D 592
Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Standard Specifications for Olive Oil-Solid Soap (Type A, Pure; Type B, Blended) (D 592 - 41 T) and affect only the requirements referred to:

Title and Text.—Omit all references to "pure" and "olive oil" through out these specifications. For making this solid soap, any oil may be used that will produce a soap conforming to the chemical composition requirements prescribed in Section 3 and in Table I of the specifications modified as indicated below.

Table I.—Change the requirement for titer of the mixed fatty acids for type A soap from:

	Type A
Titer of the mixed fatty acids prepared from the soap..	16 to 26 C.

to read as follows:

	Type A
Titer of the mixed fatty acids prepared from the soap, max...	26 C.

EA - D 593
Issued, April 6, 1942

No substitute for salt-water soap is available at present. The various producers of this soap, however, have signified their willingness to endeavor to make up products which might be suitable for use in salt water. If these new products prove acceptable, Committee D-12 on Soaps and Other Detergents will prepare specifications based on the product or products found to be most suitable for this use.

EA - D 630
Issued, April 6, 1942

The following Emergency Alternate Provisions, when specified, may be used as alternates in A.S.T.M. Tentative Specifications for Olive Oil Chip Soap (Type A, Pure; Type B, Blended) (D 630 - 41 T) and affect only the requirements referred to:

Title and Text.—Omit all references to "pure" and "olive oil" throughout these specifications. For making this chip soap, any oil may be used that will produce a soap conforming to the chemical composition requirements prescribed in Section 3 and in Table I of the specifications modified as indicated below.

Table I.—Change the requirement for titer of the mixed fatty acids for type A soap from:

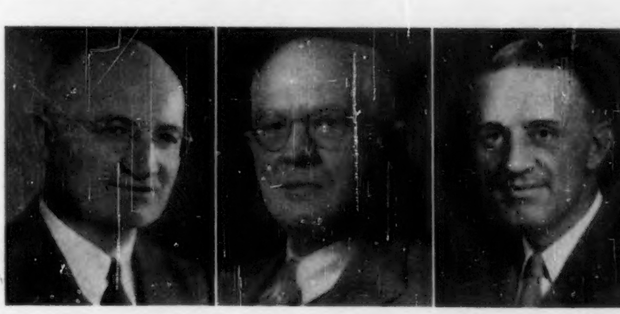
	Type A
Titer of the mixed fatty acids prepared from the soap..	16 to 26 C.

to read as follows:

	Type A
Titer of the mixed fatty acids prepared from the soap, max..........	26 C.

XXVI. Long-Time Society Committee Members
Twenty-sixth in the Series of Notes on Long-Time Members

As a continuation of the series of articles in the ASTM Bulletin comprising notes on the outstanding activities of long-time A.S.T.M. members, there are presented below outlines of the work of three additional members. In general, the men whose activities are described in this series have been affiliated with the Society for 25 years or more and have taken part in committee work for long periods of time. No definite sequence is being followed in these articles.



Hyman Bornstein   W. P. Putnam   H. F. Clemmer

Hyman Bornstein, Director of Laboratories, Deere and Co., Moline, Ill., graduated from Armour Institute of Technology with the degree of B.S. in Chemical Engineering. He later secured an LL.B. degree at John Marshall Law School and was admitted to the Illinois bar. After working as Assistant Chemist for the Union Pacific Railroad, he returned to Chicago and was employed as Engineering Chemist by the City of Chicago. During the World War he served in the Ordnance Department with the rank of Captain. Since 1920 he has been connected with Deere and Co. at Moline, Ill., in his present position. His work has been largely in the metallurgical field, including gray iron and malleable castings, steel, and heat treatments and he acts in an advisory capacity to the various plants of Deere and Co.

Mr. Bornstein has been affiliated with the Society since 1915 and for more than 20 years he has been a member of Committee A-3 on Cast Iron, having served as secretary from 1926 to 1928 and chairman, 1928 to 1936. He has also been a member of Committees A-1 on Steel since 1921, A-7 on Malleable-Iron Castings since 1931, and his membership on D-1 on Paint, Varnish, Lacquer, and Related Products dates from 1922. He has served on several sections of Committee E-1, including those on Tension Testing, Indentation Hardness, and Elastic Strength, and he represents the S.A.E. on the Joint Committee on Terms Relating to Heat Treatment.

Mr. Bornstein has been very active in the American Foundrymen's Association, serving as chairman of the Gray Iron Division, and as Director. He was President of the A.F.A. during 1937–1938, and is now a member of the Technical Activities Correlation Committee. He is a member of the Society of Automotive Engineers, and active in the Iron and Steel Division. Recently he has served as a member of a Joint Committee of S.A.E. and American Iron and Steel Institute on steel specifications. He is actively at work in phases of the War Production Boards National Emergency Steel Specifications development. His other technical society affiliations include the American Chemical Society, American Society for Metals, and American Institute of Mining and Metallurgical Engineers.

H. F. Clemmer, Engineer of Materials, District of Columbia, attended Iowa State College, from which college he graduated in 1912 with the degree of B.S. in Civil Engineering. He received the professional degree of C.E. in 1917, after a year of post graduate work and four years on the Engineering Staff of the Iowa State College. Mr. Clemmer was Engineer of Tests for the Engineering Ex-

periment Station from 1913 to 1915; Instructor in Materials, 1915–1917; Assistant Professor of Civil Engineering, 1917–1920; and was promoted to Associate Professor of Civil Engineering shortly before leaving to assume highway duties in Illinois. While with the Illinois Highway Department from 1920 to 1926, as Engineer of Materials, Mr. Clemmer was in direct charge of the research projects in connection with the tests of the Bates Experimental Road, a widely known highway research project.

From 1926 to 1930 Mr. Clemmer was associated with the Solvay Process Co. as Technical Advisor to the Sales Department. In this capacity he had direct supervision of all researches in concrete sponsored by the Solvay Co. Resigning from this position in March, 1930, Mr. Clemmer assumed his present duties as Engineer of Materials for the District of Columbia. In his present position he has direct charge of the inspection and testing of all highway and construction materials used in the District of Columbia.

Mr. Clemmer is active on a number of A.S.T.M. committees, including C-9 on Concrete and Concrete Aggregates since 1923; D-4 on Road and Paving Materials since 1922—chairman, 1932 to 1934; D-18 on Soils for Engineering Purposes since its organization in 1936; and C-1 on Cement since 1940. He has also been a member of Committee A-1 on Steel since 1934 and is chairman of and represents Committee D-4 on the Section on Flexure Testing of Committee E-1 on Methods of Testing. He is a member of Sectional Committee A37 on Road and Paving Materials of the American Standards Association, and is the A.S.T.M. representative on the Standing Committee on Simplified Practice Recommended for Coarse Aggregates of the National Bureau of Standards.

Mr. Clemmer is also affiliated with the American Society of Civil Engineers, the Highway Research Board, American Military Engineers, American Public Works Association, American Road Builders' Association, and the Federal Specifications Executive Committee.

W. P. Putnam, President, Treasurer and Technical Director, The Detroit Testing Laboratory, Detroit, Mich., received his education at Buchtel College (now University of Akron), graduating in 1893 with the degree of B.Sc. He took graduate work at Case School of Applied Science from 1894 to 1895 and upon completing this work, was connected with the Corrigan McKinney Iron Co. as chemist. Later he was chemist and metallurgist for the Superior Charcoal Iron Co. and then held these same positions with the Michigan Malleable Iron Co. He was connected with the American Radiator Co. as chemist and in 1903 organized The Detroit Testing Laboratory, with which company he has been continuously engaged in general consulting practice since its organization. During 1917 and 1918, Mr. Putnam held the commission of Major in the Inspection Division of Ordnance, U. S. Army.

Mr. Putnam has been affiliated with A.S.T.M. for over 30 years, his membership dating from 1911. He is a member of Committees A-3 on Cast Iron and A-7 on Malleable-Iron Castings, having served on A-3 since 1915 and on A-7 since 1918. He was chairman of A-7 from 1924 to 1936. Mr. Putnam represents Committee A-7 on Committee E-8 on Nomenclature and Definitions. He is an active member of the A.S.T.M. Detroit District Committee.

In addition to his membership in A.S.T.M., he is also affiliated with the American Chemical Society, American Institute of Mining and Metallurgical Engineers, Society of Automotive Engineers, American Institute of Chemical Engineers and the Detroit Engineering Society. He has served as chairman of local Detroit sections of the following organizations: American Institute of Chemical Engineers, American Chemical Society, American Foundrymen's Association, and the Detroit Engineering Society. In 1941 he received the appointment as assistant to the Detroit District Coordinator in the Federal Reserve District representing the American Institute of Chemical Engineers.

Mr. Putnam is vice-president of the American Council of Commercial Laboratories and treasurer of Universal Process Co., a research corporation. He is also a member of the Detroit Boat Club.

Physical Properties of Dental Materials

For those concerned with dental materials, a most interesting 226-page book has been issued covering the work of the National Bureau of Standards on "Physical Properties of Dental Materials." Listed as Circular C433 this publication can be obtained from the Superintendent of Documents, Washington, D. C., at 75 cents each in cloth binding.

The publication consummates 23 years of research at the Bureau in which since 1928 the American Dental Association, through its Research Commission and maintenance of a staff at the Bureau, has closely cooperated. The publication is really a condensation and résumé of more than 100 reports which have been issued since 1919. Messrs. Wilmer Souder and George C. Paffenbarger are the authors of the publication.

Joint Concrete Report in Spanish

There has recently been received a copy of the Spanish translation of the June, 1940, Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete submitting Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete. This report translated with permission of the several constituent organizations responsible for the Joint Committee has been published by the Argentine Institute of Portland Cement, which has its headquarters at Calle San Martin 1137, Buenos Aires, R. A. The report has been issued in paper and simulated leather binding.

Eastern Photoelasticity Conference

The Fifteenth Semi-Annual Meeting of the Eastern Photoelasticity Conference will be held on Saturday, June 20, 1942, at The University Club, 40 Trinity Place, Boston, Mass. All inquiries should be addressed to Prof. W. M. Murray, Room 1-321, Massachusetts Institute of Technology, Cambridge, Mass.

This Program Is Subject to Change

Provisional Program

FORTY-FIFTH ANNUAL MEETING

of the

AMERICAN SOCIETY FOR TESTING MATERIALS

ATLANTIC CITY, N. J. CHALFONTE-HADDON HALL JUNE 22 to 26, 1942

	Morning	*Afternoon*	*Evening*
Monday, June 22	Registration Committee Meetings	Committee Meetings	Committee Meetings
Tuesday, June 23	*1st* Symposium on Radiography	*2nd* Symposium on Radiography (continued) *3rd* Electrical Insulating Materials, Paint, Rubber, Textiles *4th* Water	*5th* Symposium on Radiography (continued) *6th* Plastics, Timber
Wednesday, June 24	*7th* Round-Table Discussion on Alternate Alloy Steels and Conservation of Strategic Alloys *8th* Road and Paving Materials; Bituminous Materials	*9th* Fuels and Lubricants *10th* Steel, Ferro-Alloys, Effect of Temperature *11th* 4.30 p.m. Marburg Lecture	*12th* General Session—Presidential Address; Award of Dudley Medal
Thursday, June 25	*13th* Methods of Testing, Corrosion, Fatigue	*14th* Non-Ferrous Metals	*15th* Iron *16th* Cementitious Materials
Friday, June 26	*17th* Brick, Refractories, Insulating Materials	*18th* Concrete and Concrete Aggregates	

Tuesday, June 23 9.30 a.m. First Session

Symposium on Radiography

Report of Committee E-7 on Radiographic Testing. H. H. Lester, Chairman.

Considerations being given by the committee to the preparation of recommendations on radiography of cast metal and the radiographic examination of welds and weldments are briefly discussed in this report.

Symposium on Radiography

This second Symposium on Radiography is presented in order to acquaint the engineering profession with the most recent developments in X-ray and radium radiography of engineering materials and to provide those interested with an opportunity to discuss and coordinate their ideas and methods of procedure.

Since radiography as a tool for testing materials is rather new, numerous problems have arisen since the first symposium was held in 1936, partly brought about by the phenomenal increase in the applied voltage and a more extended use of radium. But there has also been a diversification with regard to the products investigated due to the increased war industry which has given rise to numerous problems. Some radiographers have been more successful in solving these problems than others, and the exchange of ideas provided by such a symposium might contribute considerably to the war efforts. By a coordination of the work of the various laboratories a sound basis for further advances would be provided, giving radiography the standing that it deserves among the methods of testing.

Some Aspects of X-ray Inspection Applied to Testing and Production. Don M. McCutcheon, Ford Motor Co.

Describes the general application of X-ray inspection to a wide range of manufactured products requiring the use of X-ray equipment producing radiation generated by voltages from five thousand to one million volts.

While it is not claimed that the methods described are new, they represent the experiences of the author in trying out and applying the most efficient methods for large-scale production.

Since most of the author's work has to do with war production, the present paper is written mainly from that standpoint, but there is no doubt that the experiences gained will be directly applicable to future peacetime work.

Radiography of Welds and Weldments. R. E. Lorentz, Jr., Combustion Engineering Co., Inc.

The history of the development of industrial X-ray machines, culminating in the recent development of the 1,000,000-volt industrial machine, is discussed. This latest development has enabled many improvements. Not only is the X-ray no longer a severe limitation on weldable plate thicknesses, nor is it a bottleneck in production, but also better quality radiographs are being obtained.

The recent development of fine-grained, high-contrast film for use with no screens or with lead screens, in conjunction with the voltage range available, allows negatives showing very fine detail to be obtained.

Some Calibration Data and Scatter Measurements for the Radiography of Magnesium Aircraft Castings. L. W. Ball, National Research Laboratories.

The purpose of this paper is to provide radiographers who are already familiar with the X-ray examination of aluminum castings with information required for the satisfactory examination of magnesium alloy castings.

Penetration curves obtained from a slotted wedge penetrameter together with measurements of the sensitivity limits are presented. Suitable exposure factors are recommended, and a comparison is made between the results obtained with Noscreen and Screen film.

A Correlation of the Mechanical Properties and Radiographic Appearance of Magnesium Alloy Castings. R. S. Busk, The Dow Chemical Co.

An objective method for the quantitative evaluation of microporosity in radiographs of magnesium alloy castings is described. The amount of porosity appearing in test bars of two alloy compositions and three heat treatments is compared with the tensile properties. The endurance limit of one alloy is also compared with the amount of porosity. It is shown that a correlation exists between the mechanical properties measured and the microporosity.

(*Symposium continued in Second and Fifth Sessions*)

Tuesday, June 23 2 p.m. Second Session

Held Simultaneously with Third and Fourth Sessions

Symposium on Radiography (Continued)

The Application of High Voltage X-rays in the Boiler Shop. O. R. Carpenter, Babcock & Wilcox Co.

The methods used prior to million volt X-rays were inadequate for satisfactory radiographs of heavy plate. Million volt X-rays have made possible the elimination of many of the former difficulties and have shown the way to increasingly efficient radiographs at lower voltages. The Bucky grid is no longer considered essential at any plate thickness, providing the right technique is available.

The Gamma-Ray Radiography of Welded High Pressure Power Plant Piping. R. W. Emerson, Pittsburgh Piping and Equipment Co.

Power plant piping is being continually subjected to increasing temperatures and pressures. Simultaneously with the increase in working temperatures and pressures comes a demand for more rigid inspection of welded joints. More and more frequent is the demand for radiography of welded turbine leads, boiler leads and integral boiler piping.

Due to the apparently increasing popularity of this method of inspection, a discussion of the apparatus and procedure is given, together with a discussion and experimental study of sensitivity; the effect of source to film ratio, source intensity, metal thickness, and film speed as they effect sensitivity; and the most important part of radiography, interpretation of results.

Contrast and Latitude in Steel Casting Radiography with Million Volt X-rays. C. D. Moriarty, General Electric Co.

The methods commonly used in casting radiography to gain contrast or latitude are briefly discussed. The 1,000,000-volt X-ray unit with its abundance of X-ray energy permits the question of contrast and latitude to be answered economically by a choice of X-ray film. A method is described wherein it is possible for a given radiographic application to choose the type of film best suited.

(Symposium concluded in Fifth Session)

Tuesday, June 23 2 p.m. Third Session

Held Simultaneously with Second and Fourth Sessions

Electrical Insulating Materials, Paint, Rubber, Textiles

Report of Sectional Committee C59 on Electrical Insulating Materials. H. L. Curtis, Chairman.

Reports on standards being recommended for submittal to the American Standards Association for approval as American standard.

Report of Committee D-9 on Electrical Insulating Materials. T. Smith Taylor, Chairman.

Five new tentative methods included in this report cover the following: Tests for sludge formation in mineral transformer oil, general methods of testing steatite used as electrical insulation, tests for vulcanized fiber, for dimensional measurements of rigid tubes, and for power factors and dielectric constant parallel with laminations of sheet and plate insulation. Results of cooperative studies resulting in the preparation of the latter method are included. The report also includes numerous revisions in existing standards and tentative standards for electrical insulation in order to improve and bring them up to date. A number of problems being studied by the committee are also briefly discussed.

Paper Appended:

Statistical Comparison of the Methods of Determination of the Oxidation Tendency of Oils, A.S.T.M. Cooperative Tests. A. E. Flowers and S. A. Fruchtman, The De Laval Separator Co.

This paper presents a statistical comparison of the reproducibility of results obtained by different methods of test for the oxidation characteristics of insulating oils, taken from the voluminous records of the work done by Section B of Subcommittee IV on Liquid Insulation of Committee D-9 during the past sixteen years.

Report of Committee D-1 on Paint, Varnish, Lacquer, and Related Products. H. E. Smith, Chairman.

This report presents new tentative specifications for toluidine toner and a new test for abrasion resistance of organic coatings with the air blast abrasion tester. An extensive revision of the method of test for spectral apparent reflectivity of paints is included. A number of recommended changes are presented in the existing standard and tentative specifications and test methods for paint materials and five tentative standards are recommended for adoption as standard.

A New Recording Viscometer for Paint Consistency Measurements. C. R. Wicker and J. A. Geddes, Krebs Pigment and Color Corp.

A new recording viscometer rotates a cylindrical container at constant speed, so that the liquid within imparts torque to a submerged paddle connected with a spring. A lever arm records the consistency upon a moving chart. Speed can be varied in eight steps, from 30 to 285 rpm.

An Analysis of the Uranyl Oxalate Actinometer as Applied to Accelerated Light and Weathering Tests. F. T. Bowditch, C. E. Greider and C. G. Ollinger, National Carbon Co., Inc.

The usefulness of the uranyl oxalate actionometer in checking the constancy of a source of given spectral composition is pointed out and practical modifications in the method designed to simplify its use in the average laboratory are discussed.

Report of Committee D-11 on Rubber Products. O. M. Hayden, Chairman.

This report discusses the emergency alternate provisions in a number of the specifications for rubber products resulting from the order issued by the War Production Board. These cover alternate changes in five specifications for rubber insulated wire and cable and new emergency specifications for rubber sheath compounds for cords and cables. The proposed method of test for indentation of rubber by means of the durometer, which appears in the March ASTM BULLETIN is also to be recommended for publication as an emergency standard. Appended to the report is an extended abstract covering the results of the cooperative tests for accelerated light aging of rubber. The methods of testing rubber cement are recommended for adoption as standard and the report includes a number of other recommendations affecting the present standard and tentative methods for testing rubber products.

Report of Committee D-12 on Soaps and Other Detergents. H. P. Trevithick, Chairman.

This report presents three new tentative specifications for compound chip soap with rosin, compound powdered soap (granulated, with rosin), and for Type D built soap. Important revisions in a number of existing specifications are presented for action. The report also lists a number of emergency alternate provisions in the soap specifications issued early in 1942, with an explanation of the need for these emergency alternates. Appended to the report as information are extensive proposed methods of chemical analysis of industrial metal cleaning compositions.

Report of Committee D-13 on Textile Materials. H. J. Ball, Chairman.

New tentative specifications for cotton upholstery tapestries, and new methods for jute rove and piled yarn, and for identifications of finishes on textiles will be included. A new tentative method for fastness to atmospheric gases of dyes on cellulose acetate rayon is presented. An extensive revision of the test for colorfastness by laundering is being presented in the form of a new standard method of test for colorfastness to laundering and domestic washing of cotton and linen textiles which was completed in cooperation with the Sectional Committee on Fastness of Colored Textiles, sponsored jointly by the A.S.T.M. and the American Association of Textile Chemists and Colorists. The report also includes extensive revisions of methods of testing wool felt, part wool fabric, and cotton threads as well as several recommendations in other standards and tentative standards providing for improvements in the existing test methods. A proposed test for diffuse transmission of blackout material for incandescent lamp light is appended to the report as information. Tests for resistance of textile fabrics to attack by microorganisms is also included.

Sectional Committee L14 on Fastness of Colored Textiles. Jules Labarthe, Jr., Chairman.

This report announces the organization of a sectional committee under the joint sponsorship of the American Association of Textile Chemists and Colorists and the A.S.T.M. to coordinate methods of testing fastness of colored textiles to color-destroying agencies.

Tuesday, June 23 2 p.m. Fourth Session

Held Simultaneously with Second and Third Sessions

Water

Report of Committee D-19 on Water for Industrial Uses. Max Hecht, Chairman.

This progress report discusses briefly the considerations given by the committee during the year to the sampling, methods of analysis, and classification of industrial waters. Three tentative methods are recommended for adoption as standard comprising the test procedures for determining calcium ion, chloride ion, and sulfate ion in industrial waters.

Report of Joint Research Committee on Boiler Feedwater Studies. C. H. Fellows, Chairman.

This progress report discusses primarily the research project on caustic embrittlement and briefly discusses other problems that have been considered by the joint committee.

Round-Table Discussion on the Solvent Action of Water Vapor at High Temperature and Pressure

In the present-day high-pressure steam generation, boiler water temperatures approach the critical temperature of water, 706 F., and the temperature of superheated steam ranges upward, rather commonly to 925 F., and in some instances perhaps to higher values, the limiting factor being the availability of alloys stable under the extreme conditions.

Ceramic-type mineral deposits form in superheaters and turbines to the detriment of efficient and dependable operation. The source of these deposits is the material dissolved or suspended in the boiler water. How is this material transferred from the boiler water to its final location in superheaters and turbines? Is mechanical carry-over the sole explanation? What is the mechanism of its deposition? Why is silica found soluble at times, combined as sodium silicate; at other times, insoluble, uncombined, as crystalline quartz here and amorphous silica-glass there? What may we find in the physical chemistry of high temperatures and pressures which may help to explain what we actually find?

For many years, Dr. George W. Morey and his associates at the Geophysical Laboratory, Carnegie Institution of Washington, Washington, D. C., have been observing matter at high temperatures and pressures in their geophysical studies. Because of the obvious relationship of the hydrothermal synthesis of silicate rocks and the ceramic-like deposits on a turbine blade, Doctor Morey has agreed to confer informally, at this Round-Table Discussion, with engineers and chemists interested in this problem of superheater and turbine deposits. Field observations and results of some laboratory investigation and studies will be offered by a number of engineers and chemists.

Tuesday, June 23 8 p.m. Fifth Session

Held Simultaneously with Sixth Session

Symposium on Radiography (Continued from Second Session)

An Exposure Meter for X-ray Radiography. Herbert Friedman and Arthur L. Christenson, Naval Research Laboratory.

A meter has been designed for use with a G. E. 220-kv. radiographic installation, which indicates on a microammeter the X-ray intensity transmitted through specimens mounted in position for radiographing. For given brands of film and intensifying screens, the meter may be calibrated to indicate exposure times required for any desired film blackening. The receiving element of this exposure meter is a specially designed Geiger-Muller counter of high enough sensitivity to permit accurate determination of exposure time in 5 sec. Indications of the meter are independent of the geometry of the radiographic arrangement and the type of specimen material, and above 150 kv., there is little dependence on kilovoltage.

A Million Volt Portable X-ray Unit. E. E. Charlton and W. F. Westendorp, General Electric Co.

An Investigation of the Apparatus Used in Radium Radiography. L. W. Ball, National Research Laboratories; and D. R. Draper, Inspection Board of the United Kingdom and Canada.

The apparatus used in radium radiography is considered as consisting of four items. They are: (1) The source consisting of the active substance and the capsule in which it is sealed. (2) The surrounding material consisting of the walls of the room, table top, etc., together with the protective housing used to limit the spread of the radiation. (3) The cassette containing the film in contact with suitable screens. (4) The photographic equipment consisting of the film, processing solutions, and viewing lamps.

Experiments have been designed to reveal which features of each item are essential to sensitive radiography. These experiments are described, and their bearing on gamma-radiography practice is discussed.

Equivalent Penetrameters in Radiographic Testing. Robert J. Schier and Gilbert E. Doan, Lehigh University.

The present study attempts to determine with gamma rays the thickness of a penetrameter used on the *film* side of a test specimen that would be equivalent to one used on the *source* side, where it is usually placed. In radiographing pipes, where the penetrameter cannot be placed inside the pipe, this equivalent method may be useful.

The thicknesses of equivalent penetrameters to indicate 2 per cent sensitivity (as defined in the A.S.M.E. code) for steel thicknesses of $1^1/_2$, $1^3/_4$, and 2 in. are found to lie between 0.0075–0.020, 0.010–0.025, and 0.015–0.030 in., respectively.

Precision Radiography—III. Robert J. Schier and Gilbert E. Doan, Lehigh University.

The present study develops a simple equation for determining the minimum safe radiographic distance where an A.S.M.E. penetrameter is used. This equation is simpler than the general equation of Doan and Young. It is tested by experiments of which the results are tabulated.

Tuesday, June 23 8 p.m. Sixth Session

Held Simultaneously with Fifth Session

Plastics, Timber

Report of Committee D-20 on Plastics. W. E. Emley, Chairman.

This report recommends for publication as tentative the following five new methods: Tests for repeated flexural stress (fatigue of plastics), for mar resistance of plastics, for creep of plastics, for measuring photoelectrically the haze of transparent plastics, and descriptive nomenclature for objects made from plastics. Two tentative methods covering tests for index of refraction of transparent organic plastics and for water absorption of plastics are recommended for adoption as standard. A brief summary of the activities of the committee is also included.

Mar Resistance of Plastics. Ladislav Boor, American Cyanamid Co.

One of the basic physical properties of plastics now under investigation has been given the general descriptive term of "hardness." In the plastics field, the term "hardness" is used to describe many different aspects of the behavior of plastics. The method described in this paper has been given the tentative designation "Mar Resistance." A standard abrasive is allowed to drop a fixed height onto the surface of the plastic sample mounted at 45 deg. to the axis of drop. Several such abraded spots are made using increasing amounts of abrasive. The progressive degradation of the original gloss of the material is then measured by means of a simplified glossmeter of our own design. Assuming the original gloss of the material to be 100 per cent, the progressive drop in gloss is plotted against quantity of abrasive and a characteristic curve is obtained.

Mechanical Tests of Cellulose Acetate—Part II. W. N. Findley, University of Illinois

Additional mechanical tests of specimens from the same sheet of acetate for which tests were reported in the paper presented before

the Society in 1941 are reported. The following tests were conducted at constant temperature and relative humidity. Long-time extensometer creep tests show the effect of stress and aging on the creep rate. Repeated bending fatigue tests show the importance of speed of testing and range of stress on the fatigue strength. Compression tests of preconditioned specimens tested at intervals of time up to five months show the effect of initial moisture content and time on the yield point and weight.

Ignition Points of Plastic Materials. John Delmonte, Plastics Industries Technical Institute.

In conducting these tests, the ignition points of plastic materials were determined by immersing samples of plastics into heated salts at controlled high temperatures, and determining at which temperature the plastic material would burst into flames.

It has been observed that all plastic materials have an ignition point of this description, and that these ignition points are within a fairly close temperature range. Data of this nature should be useful in the work being done in establishing the burning rates of plastics.

Acid and Alkali Resistance of Plastic Materials. John Delmonte, Plastics Industries Technical Institute.

In the acid and alkali resistance tests of plastic materials, a testing technique is employed which measures physical changes in the material upon its immersion in the acid or alkali. Various concentrations of acids and alkalies are employed, and the temperature at which the most rapid attack occurs is noted.

It has been observed that there exists a great difference in the effect of acids upon plastic materials, there being an optimum concentration range which is not the greatest concentration, at which plastics are quite rapidly attacked.

The effect of conditioning and nonconditioning of plastics is also included.

Report of Committee D-6 on Paper and Paper Products. L. S. Reid, Chairman.

This report will include the following five proposed new tentative methods: conditioning procedure, tests for pentosans, for internal tearing resistance, for quantitative determination of coating, and for qualitative examination of mineral fillers and mineral coatings of paper.

Report of Committee D-7 on Timber. Hermann von Schrenk, Chairman.

This report presents a revision for immediate adoption in the standard method of test for distillation of creosote providing for the use of an electric heater and means for controlling its operation.

Stress-Strain Relations in Timber Beams. Albert G. H. Dietz, Massachusetts Institute of Technology.

Various theories have been advanced to explain the differences in the modulus of rupture, the proportional limit, and the ultimate direct compressive strength of wood parallel to the grain. Two of the more prominent theories—the Bach-Baumann, and the Newlin-Trayer fiber support theories—are examined by direct experimental measurements on carefully matched test specimens. The Newlin-Trayer fiber-aid hypothesis is in general confirmed, but certain of its basic assumptions are revised. A strain-variation curve is found, and a total elastic energy hypothesis is advanced to explain the different behavior of wooden beams and direct compression members.

Method for Inspection and Control of Liquid Starch-Base Adhesives for Bottle Labeling and Case Sealing. A. Herman and F. M. Knowlton, Joseph E. Seagram and Sons, Inc.

A procedure has been developed by which the starch-base adhesives for bottle labeling and case sealing can be controlled. The viscosity of the sample to be tested was measured by a falling-ball type viscometer. Adhesive films were spread with a Bird applicator and examined for hygroscopicity, color, plasticity, and adhesive strength. Moisture, alkalinity or acidity, and ash were determined as chemical properties.

The film examination described was found to be helpful in selecting adhesives for various applications.

Report of Committee D-17 on Naval Stores. F. P. Veitch, Chairman.

Final results of collaborative series of softening point tests on referee samples of rosins and resins using tapered and shouldered rings are presented. Results of studies on test for saponification number of dark rosin by electrometric titration and by internal and external indicators are also included.

Wednesday, June 24 9.30 a.m. Seventh Session

Held Simultaneously with Eighth Session

Round-Table Discussion on Alternate Alloy Steels and Conservation of Strategic Alloys

In order to provide the latest information with respect to the vital subject of alternate alloy steels, a round-table discussion has been arranged in which important developments will be presented by designated discussion leaders with opportunity subsequently for discussion of questions from the floor. The subject will be treated under nine headings as follows:

1. Status of raw materials—strategic elements.
2. Steps taken by the steel producer to effect conservation in the use of manganese and aluminum and other strategic elements, also any other steps taken in production methods to conserve steel, etc.
3. Outline of the work carried out by the Alloy Technical Committee of the American Iron and Steel Institute in establishing the "8000 series" alternate steels and the process used to put them in effect for adoption.
4. Steps taken to conserve alloys in aircraft engine construction.
5. Discussion on the possibilities of the use of common steel for aircraft frame construction effecting aluminum conservation.
6. Steps being taken by the bearing, automotive, bus and truck, tractor, oil drilling and production industries to effect conservation of alloys, also the work of the Research Committee on the Emergency Alternate Steels.
7. Steps taken by the Navy Dept. to effect conservation of strategic elements.
8. Course followed by the War Dept., Army Ordnance, to effect conservation of strategic elements.
9. Moves which have or are to be made to conserve elements in stainless steels.

The discussion will be completely off the record so that important information may be brought out which would not be possible if handled in a formal way. Mr. John Mitchell, Metallurgical Engineer, Carnegie-Illinois Steel Corp., will introduce the round-table discussion and act as general chairman and leader.

Wednesday, June 24 9.30 a.m. Eighth Session

Held Simultaneously with Seventh Session

Road and Paving Materials; Bituminous Materials

Report of Committee D-8 on Bituminous Waterproofing and Roofing Materials. J. M. Weiss, Chairman.

Two new specifications are recommended for publication as tentative covering coal-tar pitch for steep built-up roofs, and for asphalt saturated and coated asbestos felt for use in constructing built-up roofs. New tentative specifications for asphalt saturated asbestos felt for constructing built-up roofs are presented as a revision of the present standard. The report recommends revisions in one standard and one tentative specification and the adoption as standard of three tentative standards and the withdrawal of specifications for asphalt roofing surfaced with fine mineral granules.

Report of Committee D-18 on Soils for Engineering Purposes. C. A. Hogentogler, Chairman.

Includes a brief summary of the activities of the committee.

Report of Sectional Committee A37 on Road and Paving Materials. H. F. Clemmer, Chairman.

Reports on reorganization of the committee and considerations given to plans for the submittal to the American Standards Association of existing standards for approval as American standard.

Report of Committee D-4 on Road and Paving Materials. J. E. Myers, Chairman.

This report includes for immediate adoption revised descriptions of the tests for determination of bitumen and for proportion of bitumen soluble in carbon tetrachloride. The specifications for crushed slag for bituminous macadam base and surface courses are revised to include requirements for weight per cubic foot. The method of test for abrasion of rock by use of the Deval machine is recommended for reinstatement as tentative since this method is still being used by a number of state highway departments. Editorial changes are presented in four tentative standards. The committee is recommending that a number of the present standards and existing tentative standards be continued without change pending the completion of certain studies now under way which are expected to result in revisions.

A Rapid Method of Estimating the A.S.T.M. Ring-and-Ball Softening Point of Asphalts. A. B. Hersberger and C. Overbeck, The Atlantic Refining Co.

An A.S.T.M. softening point determination requires approximately $1\frac{1}{2}$ hr. to perform, which frequently is a disadvantage when the test is used as a control. With the method described, this softening point can be estimated for asphalts in the range of 90 to 250 F. in approximately 10 min., starting with a liquid sample. Variations in results obtained by different operators and laboratories, using both the rapid and standard tests, are compared.

Comparative Flow Studies of Rosins and Asphalts with Different Instruments. Walter Zybert, Polytechnic Institute of Brooklyn.

Wednesday, June 24 1.30 p.m. Ninth Session

Held Simultaneously with Tenth Session

Fuels and Lubricants

Report of Committee D-5 on Coal and Coke. A. C. Fieldner, Chairman.

Recommends that the standard method of laboratory sampling and analysis of coal and coke be revised to include tolerances for determination of volatile matter. The report also discusses considerations being given to volumetric methods for sulfur determination, the pulverizing characteristics of coal, and combination of the present methods of sampling coal.

Statistical Study of the Precision of Methods for Analysis of Coal and Coke. H. H. Lowry and Charles O. Junge, Jr., Carnegie Institute of Technology.

Application of statistical methods has been made to determine the precision of the procedures given in the A.S.T.M. Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 40). The numerical results reported in the paper were derived from 176 sets of determinations, including over 32,000 analyses, and should permit establishment of "permissible differences" of duplicate determinations on a single sample of coal or coke related definitely to the precision of the analytical procedures.

An Experimental Investigation of the British Standard Method for the Crucible Swelling Test for Coal. H. N. Ostborg, H. R. Limbacher, and Ralph A. Sherman, Battelle Memorial Institute.

The British Standard Method for the Crucible Swelling Test for Coal is described and results in the authors' and other laboratories on coals of the United States are presented. The particle size and small variations in the weight of the sample are shown to have little effect on the results. The principal variable that affects the swelling of the coal is the method of application of heat to the crucible. Most of the heat must be applied to the bottom and, for this reason, a gas burner is found to be more suitable than electric heating. With one exception, good check results were obtained by several laboratories on the same samples. Good correlation is found between the swelling indexes and the performance of coals on residential stokers and the indications are that the indexes are helpful in the selection of coal for industrial stokers.

Report of Committee D-3 on Gaseous Fuels. A. W. Gauger, Chairman.

This progress report summarizes briefly the considerations being given by the committee to studies of the collection and measurement of gaseous samples, determination of calorific value, specific gravity and density of gaseous fuels, determination of impurities, and water vapor content of gaseous fuels.

Report of Sectional Committee Z11 on Petroleum Products and Lubricants. T. A. Boyd, Chairman.

Reports on standards being recommended for submittal to the American Standards Association for approval as American standard.

Report of Committee D-2 on Petroleum Products and Lubricants. T. A. Boyd, Chairman.

Three proposed tentative standards included in this report cover neutralization number of petroleum products by color indicator titration and by electrometric titration; also a test for rust preventing characteristics of steam-turbine oils in the presence of water. Test results in support of the latter method are included. The test for saponification number revised to indicate the reproducibility of the test as applied to fats and fatty oils is also appended. Appended to the report as information are a proposed method of test for color of lubricating oil by photoelectric colorimeter, tests for oxidation characteristics of heavy duty crankcase oils, and a proposed test for oil content of paraffin wax, and also a further revision of the proposed test for potential gum in aviation gasoline first published in 1941.

Wednesday, June 24 1.30 p.m. Tenth Session

Held Simultaneously with Ninth Session

Steel, Ferro-Alloys, Effect of Temperature

Report of Committee A-1 on Steel. N. L. Mochel, Chairman.

Brief discussion of National Emergency Steel Specifications work; condensed reports on investigation of flattening test and determining elongation values of tubular products; listing, with brief discussion, of numerous emergency alternate provisions approved during the year. Report will include four new tentative specifications on arc-welding and gas-welding filler metal, on welded and seamless steel pipe piles, and end-quench hardenability test.

The Effect of the Rate of Drafting on the Physical Properties of Steel Wire. H. J. Godfrey, John A. Roebling's Sons Co.

This investigation was carried out with the purpose of studying the effect of various wire drawing histories on the physical properties of steel wire. The material included a 0.67 per cent carbon patented wire drawn at four rates of drafting, namely 40, 30, 20, and 10 per cent reduction per draft, and a 0.27 per cent patented rod drawn at three rates of drafting, namely, 40, 30, and 20 per cent per draft. Tension, torsion, bending, and bending-fatigue tests were made on the wire at a number of stages of wire drawing from the patented condition to over 90 per cent reduction. The investigation includes the further development of a bend testing machine for wire, and the physical properties of hand-straightened and machine-straightened wire are compared. The results of X-ray diffraction studies are also included.

Comparative Quality of Converter Cast Steels. C. E. Sims and F. B. Dahle, Battelle Memorial Institute.

Cast steel coupons from commercially produced steel made by six methods, acid and basic open hearth, acid and basic electric, side-blown converter, and side-blown converter followed by acid electric, were obtained in the raw or green condition. After normalizing they tested in tension, by low temperature notch bar impact, for strain age hardening, and low-temperature notch fatigue. The mechanical properties of the converter steels are compared with those of other similar cast steels to determine their fitness for critical uses such as ordnance.

Report of Committee A-9 on Ferro-Alloys. J. H. Critchett, Vice-Chairman.

Recommends the adoption as standard of tentative specifications for ferrochromium and also reports on consideration given to possibility of preparing specifications for other types of ferro-alloys.

Report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. Jerome Strauss, Chairman.

Recommends revisions in chemical composition requirements of the chromium and chromium-nickel sheet, plate, and strip specifications to bring them into agreement with current practice and

with the type compositions adopted by the American Iron and Steel Institute. Emergency alternate provision in three specifications for stainless steel plate and sheet issued in May, 1941, are described. Announcement is made of the completion of tables of data on the chromium and chromium-nickel steels which will shortly be published.

Report of Sectional Committee B36 on Standardization of Dimensions and Materials of Wrought-Iron and Wrought-Steel Pipe and Tubing. H. H. Morgan, Chairman.

Reports action approving seven A.S.T.M. specifications and reapproval of three specifications for pipe and piping materials recommended to the American Standards Association for endorsement as American standard.

Report of Joint Research Committee on Effect of Temperature on the Properties of Metals. N. L. Mochel, Chairman.

A brief summary of the progress made during the year in the various research projects sponsored by the joint committee. These include tests of tubular members at elevated temperatures, properties of metals at low temperatures, effect of variables on high-temperature properties of metals, comparison of short-time test methods, and a review of the present high-temperature test methods.

Report of Joint Committee on Definitions of Terms Relating to Heat Treatment. H. S. Rawdon, Chairman.

The completion on the part of this joint committee functioning under the joint jurisdiction of S.A.E., A.F.A., A.S.M., and A.S.T.M., of an extensive set of definitions of terms relating to heat treatment applicable to both ferrous and non-ferrous metals is reported.

Report of Committee A-6 on Magnetic Properties. Thomas Spooner, Chairman.

This report will include three new proposed methods which may be submitted to the Society subsequent to the annual meeting for publication as tentative: Tests for feebly magnetic materials, for measuring the core loss and permeability of materials, and for incremental permeability and core loss of flat rolled magnetic materials at low alternating inductions using 28-cm. specimens, the result of development work by the committee during the past two years. A revision for immediate adoption is recommended in the standard test for magnetic properties of iron and steel.

Paper Appended:

The Absolute Measurement of the Energy Loss in a Single Strip of Sheet Iron or Steel Under Alternating Magnetization. W. E. Shenk, United States Steel Corp.

Consideration of the requirements, which must be met if core loss is to be measured in absolute terms, led to the development of an adequate method and of apparatus, which, after use over a period of years, has proved to be accurate, sensitive, yet rugged. Its advantage over the conventional Epstein Test is that, besides yielding an absolute measure of core loss, it is nondestructive and eliminates the very appreciable effect of cold work because no shearing of the sample is required; yet the method can be adapted to a specimen of any size. This type of tester can thus be used not only for experimental investigations but also as a reliable means of grading electrical sheet.

Wednesday, June 24 — 4.30 p.m. — Eleventh Session

Marburg Lecture

Seventeenth Edgar Marburg Lecture: "Gasoline—Past, Present and Future." By Graham Edgar, Director of Research, Ethyl Gasoline Corp.

Starting with the A.S.T.M. definition of gasoline as "suitable for an internal combustion engine," this lecture discusses the close relationship between the characteristics of gasoline and the characteristics of the internal-combustion engine. The significance of the A.S.T.M. tests for gasoline is discussed together with trends of the physical and chemical nature of gasoline over a period of years, the impact of the war on gasoline, and the probable future trends in gasoline after the war.

The purpose of the Edgar Marburg Lecture is to have described at the annual meetings of the Society, by leaders in their respective fields, outstanding developments in the promotion of knowledge of engineering materials. Established as a means of emphasizing the importance of promoting knowledge of materials, the Lecture honors and perpetuates the memory of Edgar Marburg, first Secretary of the Society.

Wednesday, June 24 — 8 p.m. — Twelfth Session

General Session

Presidential Address; Award of Dudley Metal

Annual Presidential Address.
President G. E. F. Lundell, Chief, Chemistry Division, National Bureau of Standards.

Award of Charles B. Dudley Medal.
To F. C. Todd, Assistant Professor, Petroleum and Natural Gas Engineering, and A. W. Gauger, Director, Mineral Industries Research, The Pennsylvania State College.

The Sixteenth Award of the Charles B. Dudley Medal will be made to F. C. Todd, Assistant Professor, Petroleum and Natural Gas Engineering and A. W. Gauger, Director, Mineral Industries Research, The Pennsylvania State College, for their paper on "Studies on the Measurement of Water Vapor in Gases," presented before the Society at the 1941 Annual Meeting.

An annual award is made to the author or authors of a paper of outstanding merit constituting an original contribution on research in engineering materials. Established as a means of stimulating research in materials and of recognizing meritorious contributions, it commemorates the name of the first President of the Society.

Introduction of Newly Elected Officers.

The terms of the new officers, under the provisions of the By-laws, begin at the close of the annual meeting.

Recognition of Forty-year Members.

Annual Report of the Executive Committee. C. L. Warwick, Secretary-Treasurer.

A general report of Society activities with particular reference to the work of the Society in connection with the war effort, and a review of membership, publications, finances, and administrative matters relating to committee activities and inter-society relations.

Report of Committee E-10 on Standards. J. R. Townsend, Chairman.

Reports on specifications and methods of test submitted under the procedure for acceptance and publication of new and revised tentative standards and tentative revisions of existing standards in the interim between annual meetings of the Society. Also reports actions taken on issue of Emergency Standards and Emergency Alternate Provisions.

Report of Committee E-9 on Research. G. F. Jenks, Chairman.

Contains a brief discussion on the new research activities being undertaken or sponsored by Society committees, and references to the work of the several research committees.

Miscellaneous Business.

Thursday, June 25 9.30 a.m. Thirteenth Session

Methods of Testing, Corrosion, Fatigue

Report of Committee E-8 on Nomenclature and Definitions. Cloyd M. Chapman, Chairman.

This report recommends the adoption as standard of the definitions of the term screen (sieve) and records approval of recommendations for adoption of several definitions proposed by other committees. The work of the committee in reviewing definitions prepared by the Society's committees is discussed as are several considerations being given to important questions dealing with nomenclature as applied to engineering materials.

Report of Committee E-1 on Methods of Testing. W. H. Fulweiler, Chairman.

This report recommends the adoption as standard of the general methods of tension testing of metallic materials with minor revisions and several tentative specifications for thermometers, also important changes in the requirements of the high-distillation and open-flash thermometers. Announcement is made of work to be undertaken on magnaflux testing.

Activities are briefly described of the technical committees on mechanical testing, consistency and plasticity, particle size and shape, interpretation and presentation of data, designation and interpretation of numerical requirements, conditioning and weathering tests, laboratory apparatus, and hydrogen-ion concentrations.

Paper Appended:

Methods of Testing Hydrometers:

Part I—General Description of Hydrometers, Types, Scales, Etc. J. P. Bader, The Emil Greiner Co.

Existing arbitrary scales accepted in various industries, their definition and relationship to specific gravity are defined. Types of hydrometers are illustrated and described, factors governing dimensional relationship of the hydrometer body, stem and scale are explained.

Part II—Suggested Method of Testing. E. L. Peffer, National Bureau of Standards.

The paper gives an outline of the method used in the testing of hydrometers with illustration of the manner in which readings are taken.

The importance of cleanliness in hydrometry, variations due to temperature changes, complete mixing of the test liquid, and other precautions necessary to the satisfactory use of hydrometers are discussed.

Hardness Conversion Relationships. Robert H. Heyer, The American Rolling Mill Co.

The conversion relationships which are now in general use for materials in the Rockwell "B" range are not satisfactory for certain classes of materials, such as aluminum and its alloys and the austenitic stainless steels. They apply very satisfactorily to yellow brass.

Three factors which contribute to the uncertainty of present hardness conversion relationships when applied to a variety of materials having hardnesses in the Rockwell "B" range were found to be: (1) differences in work-hardening capacities; (2) differences in the contours of the hardness impressions; and (3) high rates of flow under load in the hardness test. Of these factors, the first is in most cases the most important.

Study with Recorder of Static and Dynamic Characteristics of Mechanical Vibrations. R. K. Bernhard, The Pennsylvania State College.

General specifications for instruments to record static and dynamic characteristics of mechanical vibrations are discussed. An instrument which meets these requirements has been developed The pick-up unit of this instrument is based on an electromagnetic principle, its recorder may be a standard cathode or galvanometer oscillograph. A three-way switch allows at any time a change from recording displacements to recording velocities or accelerations. By combining two pick-up units the hysteresis loop and hence phase angle and damping can be determined. Actual diagrams as well as test results are presented.

A Scanning Electron Microscope. V. K. Zworykin, J. Hillier and R. L. Snyder, RCA Manufacturing Co.

An electron microscope of the scanning type is described. An electron probe less than 100 Å. in diameter is produced by an electrostatic electron lens system and arranged to impinge on the surface of the specimen. The latter is moved mechanically in a systematic fashion so that the probe traverses each point of the area being examined. The secondary electrons which are emitted by the point of the specimen being bombarded by the probe are collected, detected, and amplified by means of fluorescent screen and multiplier phototube arrangement. The resulting signal is used to actuate a fascimile type recorder in such a way that an image of the surface of the specimen is synthesized. A number of electron micrographs produced by means of this instrument are shown.

Hydraulically Supported Spherically Seated Compression Testing Machine Platens. R. L. Templin, Aluminum Company of America.

Following a brief discussion of the problems involved in obtaining satisfactory round-end conditions in tests of columns, a new design of spherically seated fixtures is described in some detail. Some results obtained in checking the efficacy of a particular set of such fixtures of 150 tons capacity are given and certain features concerning the use of the apparatus are pointed out. From the evidence presented it is concluded that the new design offers definite advantages over previously available testing apparatus intended for similar uses.

Report of Committee A-5 on Corrosion of Iron and Steel. W. H. Finkeldey, Chairman.

Reports the completion of emergency specifications for lead coating on iron or steel hardware in the interest of conservation of zinc. An important revision in the present tentative specifications for zinc coatings on hardware and fastenings is also presented.

Additional failures of the copper-bearing and noncopper-bearing black corrugated plates exposed to the atmosphere at Annapolis since 1916 are presented. Included also are extensive tabulated data obtained from inspections of the atmospheric corrosion tests on metallic-coated hardware, structural shapes, tubular goods, etc., exposed at five locations since 1928. Further results of inspection of the atmospheric corrosion tests on the galvanized sheets are presented.

The Influence of the Combination of Principal Stresses on Fatigue of Metals. D. J. McAdam, Jr., National Bureau of Standards.

In recent papers by the author, evidence has been presented that the technical cohesive strength of a metal cannot be represented by a single stress value, but comprises an infinite number of values depending on the combination of the principal stresses. This paper discusses the relation between the three-dimensional diagram representing the influence of the combination of principal stresses on the technical cohesion limit and yield stress, and diagrams representing results of various investigations of the influence of the combination of principal stresses on the fatigue limit.

Evaluation of Fatigue Damage of Steel by Supplementary Tension-Impact Tests. J. A. Kies and W. L. Holshouser, National Bureau of Standards.

Tension-impact tests at room temperatures and at −33 C. were made on Haigh axial loading fatigue specimens of normalized S.A.E. X4130 steel after various unsafe repeated stresses at room temperature. Deleterious changes could be detected before cracks were noticeable provided that appreciable permanent sets had occurred during repeated stress. The smallest fatigue cracks studied (0.04 to 0.25 mm. maximum depth) were accompanied by substantial losses in impact resistance and elongation during impact. Average values for impact results at room temperature and at −33 C. differed only for specimens containing fatigue cracks larger than a certain size.

Fatigue Tests as a Means of Evaluating Corrosion Damage in Stainless Steel Sheets. W. H. Mutchler and J. A. Kies, National Bureau of Standards.

Flexural fatigue tests, in machines of G. N. Krouse design, were used to determine the fatigue limits on stainless steel sheet specimens before and after corrosion by prolonged exposure in marine environments. The tests showed that the corrosion was relatively rapid during the initial stages of exposure, but that thereafter a near arrest in the attack occurred. Panels exposed to the marine atmosphere suffered more damage, for the same period of exposure, than those which were wet periodically by tidewater. The method permitted a reliable evaluation of the damage resulting from corrosion.

Report of Research Committee on Fatigue of Metals. H. F. Moore, Chairman.

This report will present data obtained in the study of size effect on fatigue strength.

Report of Committee E-4 on Metallography. L. L. Wyman, Chairman.

Presents revisions in the methods of preparation of metallographic specimens which will include electrolytic polishing methods. Changes are also recommended in the methods of preparation of micrographs of metals and alloys to cover improvements and schematic diagrams on better methods of illustrating specimens. Progress is reported on completion of a recommended practice for X-ray diffraction (powder analysis) and procedures for nonmetallic inclusions in steel which will cover the magnaflux methods as a macroscopic test, and a microscopic procedure to be based on the S.A.E. procedure.

Thursday, June 25 2 p.m. Fourteenth Session

Non-Ferrous Metals

Report of Committee B-8 on Electrodeposited Metallic Coatings. E. M. Baker, Chairman.

This progress report discusses considerations given by the committee to studies of the industrial need for specifications for electroplated coatings.

Report of Committee B-7 on Light Metals and Alloys, Cast and Wrought. Sam Tour, Chairman.

This progress report submits several important changes in the chemical requirements for alloy "O" in the tentative specifications for aluminum-base alloy sand castings. Considerations given by the committee to the other specifications for aluminum and magnesium alloys under its jurisdiction are briefly discussed.

Report of Committee B-6 on Die-Cast Metals and Alloys. J. R. Townsend, Chairman.

Recommends the adoption as standard of the tentative specifications for aluminum-base alloy die castings. Reference is made to an emergency alternate provision in these specifications providing for an alternate alloy No. VII-B as a substitute for alloy No. VII. Details are given of emergency alternate provisions in the specifications for zinc-base alloy die castings providing two alternate alloys for the present alloys Nos. XXIII and XXV with the aluminum content restricted to from 1.5 to 3.5 per cent in order to conserve aluminum during the war emergency.

Paper Appended:

Fatigue Testing of Zinc-Base Alloy Die Castings. E. H. Kelton, The New Jersey Zinc Co. (of Pa.)

To satisfy the occasional demands for endurance limit of the zinc die-casting alloys, fatigue tests were conducted on specimens after three conditions of aging.

The methods of testing on a flexure type and on a rotating cantilever beam type machine are described.

The intepretation of data and endurance values are given.

Report of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys. Dean Harvey, Chairman.

This report presents three new and revised proposed tentative standards, as follows: Specifications for round nickel wire for lamps and electronic devices, tests for lateral wire for grids of electronic devices, tests for nickel and nickel-alloy wire and ribbon for electronic tube filaments. There are appended to the report as information proposed specifications for chromium-nickel-iron alloy castings for high-temperature service and a method of test for effect of controlled atmospheres upon alloys in electric furnaces. The adoption as standard of methods of testing sleeves and tubing for radio tube cathodes is recommended.

Report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. Sam Tour, Chairman.

A progress report containing brief references to studies being carried on by the committee on total and alternate immersion tests, atmospheric exposure tests, and the galvanic and electrolytic corrosion studies.

Report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought. C. H. Greenall, Chairman.

This report describes the emergency alternate brass and bronze casting alloys prepared in response to requests from the War Production Board in the interest of conserving tin. The activities of the committee in cooperating with various Government agencies is discussed. Recommendations affecting standards include revisions in eight tentative specifications, the adoption of two tentative standards, and revisions for immediate inclusion in three standards.

Report of Committee B-1 on Copper and Copper-Alloy Wires for Electrical Conductors. J. H. Foote, Chairman.

Recommends for publication as tentative the specifications for lead and lead-alloy coated wire accepted by the Society as an emergency standard in April, 1942. Revisions in the tentative specifications for rope-lay-stranded and bunch-stranded copper cables for electrical conductors are presented in which these specifications are divided into three separate standards covering the different types of stranded cable. Includes new tentative specifications for tinned hand-drawn and medium hand-drawn copper wire.

The Creep Characteristics of Some Copper Alloys at Elevated Temperatures. H. L. Burghoff, A. I. Blank and S. E. Maddigan, Chase Brass and Copper Co.

This paper presents the results of creep tests upon seven wrought copper alloys at 300, 400 and 500 F. The test materials included 70–30 brass, silicon bronze (3 per cent silicon), 85–15 brass, naval brass, admiralty, phosphor bronze (5 per cent tin), and 70–30 copper-nickel. These were prepared in various tempers to permit evaluation of the effect of grain size in annealed tempers and of degree of reduction in drawn tempers. The microstructures and room temperature physical properties of all materials were determined before and after exposure in the creep tests.

The 70–30 copper-nickel alloy has outstandingly better creep-resisting characteristics than any of the other alloys tested.

Report of Committee B-2 on Non-Ferrous Metals and Alloys. E. E. Thum, Chairman.

The completion of emergency alternate solder metal compositions and also of alternate white bearing metal (babbitt metal) alloys in the interest of the conservation of tin are described. This progress report also records the completion of proposed emergency specifications for fire-refined copper of the so-called "Braden" type.

Report of Committee E-2 on Spectrographic Analysis. H. V. Churchill, Chairman.

This progress report discusses briefly the considerations being given by the committee to fundamental methods and technique; also quantitative methods and their application, and accessory uses of the spectograph.

Report of Committee E-3 on Chemical Analysis of Metals. G. E. F. Lundell, Chairman.

Completely revised analytical procedures for aluminum and aluminum alloys and an extensive description of new chemical methods for analysis of magnesium and magnesium alloys are presented.

Thursday, June 25 8 p.m. Fifteenth Session

Held Simultaneously with Sixteenth Session

Iron

Report of Committee A-7 on Malleable Iron Castings. F. L. Wolf, Chairman.

New proposed tentative specifications for malleable iron castings for flanges, pipe fittings, and valve parts are included in this report. Records reapproval of the existing standard specifications for malleable iron castings and their submittal for approval as American standard by the American Standards Association. Discusses further study of pearlitic malleable irons.

Some Creep Studies on Cupola Malleable Cast Iron. J. J. Kanter and Glen Guarnieri, Crane Co.

In view of the apparent lack of creep information on malleable irons, a series of high-temperature studies on cupola malleable cast iron is reported. These studies indicate that this material makes a very creditable showing in relation to the accepted values for silicon-killed carbon steel, having two-thirds creep strength at 800 F. The allowable working stress for malleable iron, based upon creep studies using an established policy of determining design stress, justifies 5600 psi. up to 775 F., a value several times that used in current designs limited to 450 F. maximum service temperature.

Report of Committee A-3 on Cast Iron. J. W. Bolton, Chairman.

The report presents revisions in the standard specifications for gray iron castings for valves, flanges, and pipe fittings to bring them into agreement with the general specifications for gray iron castings. Two obsolete specifications recommended for withdrawal cover cast-iron locomotive cylinders, and chilled-tread cast-iron wheels. Minor revisions are presented in the tentative recommended practice for evaluating the microstructure of graphite in gray iron.

Paper Appended:

Compression Testing of Cast Iron. W. Leighton Collins, University of Illinois.

The paper is prepared as a contribution to the work of Subcommittee XI, of Committee A-3 on Cast Iron, in preparing a recommended practice for compression testing of cast iron. The compression tool used satisfactorily at the University of Illinois is described, as well as the type of specimen and method of testing. Some of the questions arising in the preparation of a recommended practice are also presented.

Informal Report of Sectional Committee A21 on Specifications for Cast-Iron Pipe and Fittings. T. H. Wiggin, Chairman.

Completion by this sectional committee of proposed American standard specifications for cast-iron pipe centrifugally cast in metal molds for water or other liquids, threaded pipe, tapered machined joint pipe, and pipe horizontally cast, will be briefly discussed together with other activities of the sectional committee.

A Study of the Chemical, Physical and Mechanical Properties of Permanent Mold Gray Iron. Richard Schneidewind, University of Michigan; and Edward C. Hoenicke, Eaton Manufacturing Co.

The Effect of Stress Concentration on the Fatigue and Static Strengths of Alloyed Cast Irons. W. Leighton Collins and James O. Smith, University of Illinois.

Unnotched and notched specimens from four different cast irons were subjected to bending, torsional, and axial repeated loads and to static loads in tension, compression, and torsion. The notches were mechanical—small diametral hole or circumferential V-groove—and chemical—corrosion due to a stream of fresh tap water. Stress concentration factors for the various types of loads and stresses are given, as well as chemical compositions and typical photomicrographs of the irons. The data indicate that stress concentration factors can be as high as 2.8 for some irons and establish the fact that not all cast irons can be arbitrarily said to be insensitive to the damaging effects of notches when repeated loads are being resisted.

Report of Committee A-2 on Wrought Iron. C. B. Bryant, Chairman.

Recommends adoption as standard of Tentative Specifications for Single and Double Refined Wrought-Iron Bars (A 189 – 39 T) and reaffirms without change four existing standard specifications.

Thursday, June 25 8 p.m. Sixteenth Session

Held Simultaneously with Fifteenth Session

Cementitious Materials

Report of Committee C-1 on Cement. P. H. Bates, Chairman.

A new test for sulfide sulfur and a new alternate method for sodium and potassium oxides in cement are recommended for publication as tentative. An interesting summary is presented of considerations being given by the committee to other analytical procedures, alkalies in cement, air permeability methods for determining fineness, size of batches for tensile and compressive strength tests, additions to cement, specifications for portland-pozzuolana cements, sulfate resistance tests for cement, and the inspection work of the cement reference laboratory.

Long-Time Volume Changes of Portland-Cement Bars. Alfred H. White and Harold S. Kemp, University of Michigan.

This paper presents a continuation of the studies on volume changes of portland cement reported in the A.S.T.M. *Proceedings* for 1911, 1914, and 1928. There are available for study over 450 bars of known history which have been observed for periods ranging from 17 to 41 yr. The cements include a variety of commercial cements, and cements made in the laboratory whose composition differs in some cases quite widely from those found in commerce. A selection of 185 bars was made nearly 2 yr. ago for a special further study which involved alternations of the bars between the wet and dry states, with autoclave tests for some of the bars. Special attention was paid to the group carrying abnormally high magnesia, but cements of normal composition were also included.

Theory and Measurement of Plasticity and Workability of Mortars. Paul S. Roller, Bureau of Mines, U. S. Department of the Interior.

The plasticity of mortars was measured on the basis of a stress-strain relation which previously had been formulated and applied extensively. Two constants are determined: coefficient of renitence, K (or its inverse, coefficient of plasticity), and yield value, p_0, the minimum pressure required for plastic flow.

Values of K for masonry cement mortars were compared with a mason's ratings and with results by other methods of measurement. The effects were also studied of change in type of cement, of cement-sand ratio, and of addition of powdered minerals and organic reagents.

Water retentivity was shown to be correlated with plasticity. Greater increases in water retentivity for a given increase in plasticity were apparently caused by the addition of mineral powders than of organic reagents.

Curing of Masonry Mortars. Howard R. Staley, Massachusetts Institute of Technology.

The effect of variations in curing conditions upon the 7- and 28-day compressive strength of 2-in. mortar cubes is reported. The mortars were made using three hydrated limes and one brand of portland cement in proportions by volume, varying from $^1/_4$ to 3 parts of lime to 1 part of cement. Fourteen treatments during the curing period have been used for the foregoing mortars. The effect of four treatments during curing upon the strength of straight-lime mortars is also reported.

The Effect of Brick Absorption Characteristics upon Mortar Properties. F. O. Anderegg, Owens-Corning Fiberglas Corp.

The characteristics of brick absorption are discussed relative to the number and size of the pores, both for free water and for the moisture in mortars. The volume and force components of the suction are tied in with the number and size of the pores. The resistance to flow is correlated with pore diameter, with the formation of a dense, congealed layer at the mortar unit interface, with the water-retaining capacity of the mortar, and with viscosity of the water. Some of the results from the congealing effect are discussed and the importance of wetting units having high absorption rates is emphasized. The effects of the absorption on bond strength and on joint-mortar compressive strength and on mortar durability are developed and their relation to the compressive strength of metal-molded cubes is brought out.

Report of Committee C-7 on Lime. N. C. Rockwood, Chairman.

This progress report discusses the considerations being given by the committee to revisions in the standard specifications for hydrated lime for structural purposes; also to studies of lime in mortar, and mortar strength tests. Discusses work under way on development of additional methods of test including procedures for determining available lime, for arsenic, fluorine, and lead in lime, methods of slaking quicklimes, and settling rates of lime products. Reports preparation of a series of definitions covering lime and lime products.

Report of Committee C-11 on Gypsum. L. S. Wells, Chairman.

The recommendations affecting standards included in this report comprise revisions in the specifications for calcined gypsum for dental plasters, gypsum lath, gypsum wall board, and gypsum sheathing board, and in the methods of testing gypsum products. The definition of perforated gypsum lath as revised is recommended for adoption as standard. The report discusses work being undertaken on water permeability of gypsum sheathing board and a study of subsieve fineness of gypsum particles.

Report of Committee C-12 on Mortars for Unit Masonry. J. W. McBurney, Chairman.

New proposed tentative specifications for mortar for cement masonry units are included in this report. Revisions recommended in the tentative specifications for aggregate for mortar will clearly define limits of gradation.

Friday, June 26 9.30 a.m. Seventeenth Session

Brick, Refractories, Insulating Materials

Report of Committee C-14 on Glass and Glass Products. G. W. Morey, Chairman.

This report presents a brief summary of the progress of the considerations being given by the committee to studies of chemical analysis and chemical properties of glass, and to the physical, mechanical, and thermal endurance of glass and glass products.

Report of Committee C-18 on Natural Building Stone. W. C. Clark, Chairman.

This progress report discusses considerations being given by the committee to definitions relating to natural building stone, quality specifications, and additional test procedures; also work under way on surface finishes, cubing, and stone setting and maintenance.

Report of Committee C-15 on Manufactured Masonry Units. D. E. Parsons, Chairman.

This report presents for publication as tentative a test procedure for determining initial rate of absorption (suction) of brick which is needed in connection with specifications for masonry walls. The tentative specifications for sewer brick and for paving brick are recommended for adoption as standard without revision.

Paper Appended:

Relations Between Results of Laboratory Freezing and Thawing and Several Physical Properties of Certain Soft-Mud Bricks. John W. McBurney, National Bureau of Standards.

A sample of 50 bricks representative of the production of 10 plants making soft-mud bricks from surface clay was subjected to the various tests prescribed by the current A.S.T.M. specifications. Additional tests were made using the methods of Stull and Johnson. Freezing-and-thawing tests were made until 175 cycles were completed. The results of 50 cycles and 175 cycles were compared and the relations between these results and the previously measured properties were considered. The relation between results of freezing and thawing and properties is much more definite for 175 cycles than for 50 cycles in so far as relations exist for particular properties.

Report of Committee C-8 on Refractories. J. D. Sullivan, Chairman.

New tentative specifications for fire clay plastic refractories for boiler furnaces and incinerator service are presented in this report which also recommends the adoption as standard of definitions relating to refractories, of the test methods for insulating fire brick, and of the tentative revisions in the tests for pyrometric cone equivalent and the three panel tests for structural spalling.

Report of Committee C-16 on Thermal Insulating Materials. J. H. Walker, Chairman.

This progress report discusses considerations being given by the committee to the preparation of emergency specifications for preformed block type thermal insulating materials; thermal insulating cements of all types; blanket type, flexible and loose filled thermal insulating materials; and for structural insulating board. Announces the completion of the guarded hot plate method for determining thermal conductivity of various types of thermal insulation prepared jointly by the A.S.H.V.E., A.S.R.E., A.S.T.M., and National Research Council.

Code for the Determination of Thermal Conductivity by Use of the Guarded-Hot Plate Apparatus. F. C. Houghten, American Society of Heating and Ventilating Engineers.

Friday, June 26 2 p.m. Eighteenth Session

Concrete and Concrete Aggregates

Sanford E. Thompson Award

Report of Committee C-9 on Concrete and Concrete Aggregates. F. H. Jackson, Chairman.

This extensive report presents as tentative new specifications for waterproof paper for curing concrete, methods of sampling fresh concrete, methods of measuring length of drilled concrete cores, and test for air content of freshly mixed concrete. Other recommendations on standards include three new definitions, adoption of tentative specifications for ready mixed concrete with revisions, amendments in three standards, and revisions in two tentative standards. Announcement is made of the completion of the report on significance of tests of concrete and concrete aggregates to be published shortly. Extensive studies made on the measurement of cores drilled from concrete which resulted in preparation of the new method are described in an Appendix.

Sanford E. Thompson Award:

To John Tucker, Jr., Chief, Concreting Materials Section, National Bureau of Standards.

The Third Sanford E. Thompson Award will be made to John Tucker, Jr., Chief, Concreting Materials Section, National Bureau of Standards, for his paper on "Statistical Theory of the Effect of Dimensions and of Method of Loading upon the Modulus of Rupture of Beams," presented before the Society at the 1941 Annual Meeting. The Sanford E. Thompson Award was established in 1938 by Committee C-9 on Concrete and Concrete Aggregates as an annual token of recognition to the author or authors of a paper of outstanding merit on concrete and concrete aggregates presented at an annual meeting of the Society. The award is named in honor of the first chairman of the committee.

The Influence of the Durability of Aggregate upon the Durability of the Resulting Concrete. H. H. Munger, Kansas State College of Agriculture and Applied Science.

The value of the ordinary laboratory test for soundness by freezing and thawing was investigated by comparing the results of tests of 14 different aggregates with the results of tests of the resulting concrete. The dynamic modulus of elasticity was taken as the index of durability of the concrete and is compared with the modulus of rupture and compressive strength. Data are presented that indicate that the soundness test of aggregate, *per se*, is not a dependable criterion of durability of the resulting concrete. Thermal shock is indicated as an important factor in laboratory tests. Soundness tests of concrete mixed in proportions to be used on the job are recommended.

Effect of Height of Test Specimens on Compressive Strength of Concrete. James W. Johnson, Iowa State Highway Commission.

A.S.T.M. Standard Method of Securing Specimens of Hardened Concrete from the Structure (C 42 – 39) prescribes correction factors to be applied to the compressive strength values of specimens of various heights. This paper reports the results of a study to determine the reliability of some of these factors and to determine whether the loss of compressive strength with increase in height of cylindrical specimens cast with their long axes vertical may be due to water gain in the taller specimens.

The results reported indicate that the standard correction factors are reliable for all values of h/d except 1.00, and those in excess of 2.00. They also show some indication that loss of compressive strength of tall cast specimens made from concrete of wetter consistencies may be due to water gain.

Factors Influencing the Reflectivity of White Portland Cement Concretes. C. W. Muhlenbruch and E. H. Miller, Carnegie Institute of Technology.

The reflectivity of white cement concretes now in wide use for curbs and other reflecting surfaces is affected by various types of aggregates, water-cement ratio, method of curing, and method of finishing. Freezing-and-thawing and exposure tests of 150 summer, and 100 winter days show that loss of reflectivity may be as high as 70 per cent. Various ratios of light and dark sand to cement give information useful in designing a mix. The effect of five dispersing or wetting agents on reflectivity, normal consistency, and strength has been studied. Wetting agents, when added in the amount of 1 per cent by weight of mixing water overcome the difficulty of mixing white waterproof-type cement without affecting the properties.

A Test for the Effect of Coarse Aggregate on the Resistance of Concrete to Freezing and Thawing. E. O. Axon, F. V. Reagel and T. F. Willis, Missouri State Highway Dept.

This paper describes a series of investigations, the purpose of which was the development of a test that would evaluate the effect of the coarse aggregate on the resistance of concrete to freezing and thawing.

Powdered Aluminum as an Admixture to Concrete. Roy W. Carlson, Massachusetts Institute of Technology.

When aluminum powder is added to a fresh concrete mix, the reaction of the aluminum and the mixing water releases hydrogen gas. This paper is concerned with such small additions of aluminum that there is very little change in the density of the concrete. When roughly 0.01 per cent of aluminum is used, the effect is mainly to create some internal expansion of the cement paste during hardening and to remove the usual "water gain" under aggregate particles and reinforcing bars. The net result is that compressive strength is not greatly affected, but some properties, especially bond to reinforcing steel, are improved. Furthermore, when the amount of aluminum powder is such as to reduce the weight of the concrete several per cent, greatly increased resistance to freezing and thawing (in $CaCl_2$) is found, without serious decrease in strength.

The paper shows the effect of amount, fineness, and method of adding aluminum powder, upon the properties of concrete. Tests are reported on aluminum interground with a number of different clinkers, as well as simply admixed to the concrete. The rate at which gas is liberated by the aluminum reaction is shown for a variety of cements and conditions.

Miscellaneous Business.

Pittsburgh District Has Successful Meeting on Petroleum, Rubber, Standards

THREE INTERESTING talks, one on Materials Standards and the War, another Rubber and the War, and a third dealing with the importance of gasoline and related problems featured the meeting sponsored by the A.S.T.M. Pittsburgh District Committee, March 30, in the Mellon Institute Auditorium. Upward of 250 committee members and guests attended the meeting. Preceding the technical session, members of the District Committee and guest speakers had dinner at the University Club.

Following a short discussion by R. J. Painter, Assistant to the Secretary, A.S.T.M., who pointed to some of the important material in the March ASTM BULLETIN, the second number issued under wartime conditions, and stressed other important phases of A.S.T.M. work, there was a most interesting discussion on rubber by Arthur W. Carpenter, Consultant, Conservation and Substitution Branch, Bureau of Industrial Conservation. Mr. Carpenter is Secretary of A.S.T.M.'s Committee D-11 on Rubber Products. He brought home very forcefully to those present the serious situation with respect to supply. With so much of the normal crude coming from Malaya and the East Indies cut off and the very small percentage of our needs available from other sources including Brazil, Ceylon, Liberia, and from various North American sources including Mexican guayule, the importance of synthetic rubber was evident.

Mr. Carpenter considered the reclaim situation stressing the importance of developing adequate scrap from which to get reclaim, and by certain statistics and discussion definitely left his audience with a much clearer conception of just what we were facing. He stressed one point which certainly has needed emphasis, namely, to judge the situation on the basis of facts and not by newspaper versions, or estimates given by "amateurs," etc.

Mr. Whitney Weinrich, Assistant Head, Chemistry Division, Gulf Research and Development Co., outlined in his address, illustrated with slides, what is being done in connection with various grades of gasoline, particularly the so-called 100 octane type needed to set up and maintain our air supremacy in the present emergency and how important petroleum contribution is in this program. Through process diagrams, he showed how the various products were obtained. In discussing various methods of production, his talk tied in nicely with Mr. Carpenter's because he indicated generally the great amount of equipment necessary to produce the petroleum fractions required in synthetic rubber products. Mr. Carpenter had previously stressed that this definitely was a crucial point in determining how fast and in what volume we could get the required synthetic products.

Dr. G. E. F. Lundell, A.S.T.M. President and Chief, Chemistry Division, National Bureau of Standards, discussed Materials Standards and the War, indicating the great amount of work under way. He referred to the work of the Society in this field, particularly the National Emergency Steel Specification work and also gave statistical summaries of efforts of the National Bureau of Standards and other government divisions and industrial organizations. In the course of his discussion, Dr. Lundell paraphrased General Sherman's famous statement, indicating that "war is hell on standards" at which there were numerous nods of agreement from the audience, many of whom were active in the development of specifications and tests.

F. M. Howell, Aluminum Company of America and Chairman of the Pittsburgh District Committee, presided. He and H. A. Ambrose, Gulf Research and Development Co., Secretary of the District Committee, developed plans for the meeting in cooperation with other district members including Dr. S. M. Phelps, Mellon Institute of Industrial Research.

The meeting closed with the showing of the sound, color movie "Unfinished Rainbows" featuring the story of aluminum.

Book on Definitions of Electrical Terms

RECENTLY ISSUED by the American Institute of Electrical Engineers is a new publication entitled "Definitions of Electrical Terms" which gives a glossary resulting from many years of work of a sectional committee of some 50 members with a number of subcommittees. Three hundred individuals cooperated in the work representing some 34 organizations. The sectional committee was sponsored by the A.I.E.E. under the rules of the American Standards Association. The definitions have recently been approved as American Standard with the designation C42.

The primary aim in the formulation of the definitions has been to express for each term the meaning generally associated with it in electrical engineering in America. The definitions have been generalized wherever practicable to avoid precluding the various specific interpretations which may be attached to a term in particular applications. It has been recognized that brief, simplified phrasing usually presents the clearer word picture.

The book contains some 300 pages, is available in dark blue fabricoid binding, and is thoroughly indexed. Copies can be obtained from the A.I.E.E. Headquarters, 33 West 39th St., New York, N. Y., at $1 in the United States, and $1.25 outside the country. Checks or money orders should be made payable to the A.I.E.E.

Sand and Gravel Fellowship at Maryland

AN ANNOUNCEMENT has been received of the continuance of the Stanton Walker Fellowship of the National Sand and Gravel Association at the University of Maryland for the next two years. The Fellowship which involves research on problems related to the sand and gravel industry amounts to $600 and is paid in twelve monthly installments. It is open to graduates in engineering. Application forms may be secured by writing to the Dean of the Graduate School, University of Maryland, College Park, Maryland.

Sustaining Members Now Total 148

With the addition of the two sustaining members announced below, the total in this class reaches a new high, 148. These new members will receive the same rights and privileges as outlined in previous issues of the Bulletin.

New Sustaining Members

General Dyestuff Corp., H. W. Martin, Secretary, New York, N. Y.

This leading organization has been mainly concerned with two phases of A.S.T.M. work, namely, textile materials and soaps and other detergents which are covered through the work of Committees D-13 and D-12, respectively. The company is represented on the textile group by J. Robert Bonnar, who serves on Subcommittee B-4 on Bleaching, Dyeing, and Finishing.

George H. Alpers is the company representative on Committee D-12 serving on Section E which is responsible for specifications for sulfonated detergents and on Section A on Soaps of Subcommittee I on Methods of Testing.

Newport Industries, Inc., R. C. Palmer, Chemical Director, Pensacola, Fla.

This very extensive organization with offices and plants in leading centers is concerned especially with naval stores and related products. The company membership in the Society dates from 1925 during which time R. C. Palmer, Chemical Director, has been the official representative.

Mr. Palmer represents his company on Committee D-17 on Naval Stores and its Subcommittees I on Softening Point of Rosin and IV on Acid and Saponification Numbers and Unsaponifiable Matter.

New Members to May 1, 1942

The following 46 members were elected from March 20 to May 1, 1942:

Chicago District

Accurate Spring Manufacturing Co., E. H. Runden, Jr., Design Engineer, 3811 W. Lake St., Chicago, Ill.

Brown, Arthur J., General Engineer, Whiting Corp., Harvey, Ill.

Harrington, J. Earl, Chemical Engineer, Greeley & Hansen, 6 N. Michigan Ave., Chicago, Ill.

Schauwecker, K. F., Metallurgical Contact Representative, Carnegie-Illinois Steel Corp., Chicago, Ill. For mail: 1840 N. Prospect Ave., Milwaukee, Wis.

Cleveland District

Taylor-Winfield Corp, The, R. C. Woods, Director of Research, Warren, Ohio.

Detroit District

American Propeller Corp., H. P. Moyer, Metallurgist, 1333 Alexis Road, Toledo, Ohio.

Nielsen, Claudius, Director of Research, Mercury Chemical Co., Detroit, Mich. For mail: 19720 Florence Road, Detroit, Mich.

New York District

Harris and Co., Harry, 33 Passaic Ave., Kearny, N. J.

Tube Reducing Corp, R. Heinzerling, Metallurgist, Box 327, Passaic, N. J.

Campi, A. Edward, Molding Engineer, Plastics Division, American Cyanamid Co., Bound Brook, N. J.

Clay, Wharton, Secretary, National Mineral Wool Assn., 1270 Sixth Ave., New York, N. Y.

Foulke, J. L., Chief Chemist, A. & M. Karagheusian, Inc., Freehold, N. J.

Mancini, Vincent, 1913 Sixty-first St., Brooklyn, N. Y.

McMahon, E. J., Marine Boiler Design Engineer, Combustion Engineering Co., Inc., New York, N. Y. For mail: 117-14 Nashville Ave., St. Albans, L. I., N. Y. [J]*

* [J]—denotes Junior Member.

Norton, R. B., Research Engineer, Kerite Insulated Wire and Cable Co., Seymour, Conn. For mail: 85 Grand St., Seymour, Conn.

Repp, R. N., Laboratory Manager, Haller Engineering Associates, Inc., New York, N. Y. For mail: 1121 Sherman Ave., Plainfield, N. J.

Philadelphia District

Florence Pipe Foundry and Machine Co., D. J. Peake, Vice-President and Superintendent, Florence, N. J.

Dearnley, C. E., President, Dearnley Bros. Worsted Spinning Co., Chelten Ave. and Baynton St., Germantown, Philadelphia, Pa.

Ostertag, J. L., Chief Draftsman, W. K. Mitchell and Co., Inc., 2940 Ellsworth St., Philadelphia, Pa.

Pittsburgh District

Baker, C. R., Supervisor of Specifications, National Tube Co., First St., Ellwood City, Pa.

St. Louis District

Phelan-Faust Paint Manufacturing Co., F. C. Weber, Jr., Assistant Technical Director, 932 Loughborough Ave., St. Louis, Mo.

Southern California District

Bechtold, I. C., Process Engineer, The Fluor Corp., Ltd., Box 7030, East Los Angeles Branch, Los Angeles, Calif.

U. S. and Possessions

Other than A.S.T.M. Districts

Aero Parts Manufacturing Co., J. E. Viscardi, Director of Research and Development, 255 N. Water St., Wichita, Kans.

Albany Felt Co., J. C. Standish, Superintendent, 1333 N. Broadway, Albany, N. Y.

Durfee Co., Inc., W. C., W. C. Durfee, President, 114 Federal St., Boston, Mass.

Engineers and Fabricators, Inc., E. E. Dillman, Secretary-Treasurer, Box 7395, Houston, Tex.

Plymouth Rubber Co., M. M. Danovitch, Chief Chemist, Revere St., Canton, Mass.

Will Corp., W. E. Dalton, Vice-President, Rochester, N. Y.

Asnin, J. I., Junior Mechanical Engineer, U. S. Navy Dept., Washington, D. C. For mail: 2328 Nineteenth St., N. W., Washington, D. C. [J]

Brown, Thomas C., Chief Chemist and Research Director, Sheller Manufacturing Corp., Portland, Ind.

Cuerdon, T. Joseph, Jr., Assistant Chemist, Chesapeake & Ohio Railway Co., Huntington, W. Va. For mail: 1203 Ninth Ave., Huntington, W. Va. [J]

Elving, P. J., Assistant Professor of Analytical Chemistry, Department of Chemistry, Purdue University, Lafayette, Ind.

Keane, T. Joseph, Testing Engineer, Russell Manufacturing Co., Middletown, Conn.

McLeod, E. D., Assistant Technical Director, Arnold-Hoffman and Co., Inc., Providence, R. I. For mail: 125 Miller Ave., Rumford, R. I.

Miller, Ernest C., Oil Technician, West Penn Oil Co., Warren, Pa.

Pope, C. L., Lubrication Engineer, Eastman Kodak Co., Kodak Park, Rochester, N. Y.

Taylor, R. H., Assistant Physicist, National Bureau of Standards, Washington, D. C.

Urbanetti, A. J., Chief Chemist, The Rogers Paper Manufacturing Co., Manchester, Conn. For mail: 82 W. Center St., Manchester, Conn.

Other than U. S. and Its Possessions

Peacock Brothers Limited, F. A. Peacock, Vice-President, Box 6070, Montreal, P. Q., Canada.

Cade, G. N., Inspector General's Representative, Inspection Board of United Kingdom of Canada, c/o Canadian National Railways Munitions Ltd., Point St. Charles, Montreal, P. Q., Canada. For mail: 250 Regina St., Verdun, P. Q., Canada.

Critchley, J. A., Plant Manager, Sorel Steel Foundries, Ltd., Sorel, P. Q., Canada.

Müller, E. G., Assistant Engineer of Materials Testing Laboratories of the Engineering Faculty, Universidad Nacional de Tucumén, Calle Salta 470, Tucumén, Argentina.

Riendeau, Douglas, Physical Tester, Ontario Research Foundation, Toronto, Ont., Canada. For mail: 2 Spadina Road, Apartment J, Toronto, Ont., Canada. [J]

Western Australian Government Railways, Frederick Mills, Chief Mechanical Engineer, Perth, Western Australia.

White, W. S., Superintendent, Sorel Steel Foundries, Ltd., Sorel, P. Q., Canada.

Williams, P. M., Manager, Cementos Guadalajara, S. A., Apartado 1404, Guadalajara, Jal., Mexico.

PERSONALS

• • • News items concerning the activities of our members will be welcomed for inclusion in this column.

Correction in March "Personals"

In the "Personals" column on page 70 of the March ASTM Bulletin, it was stated that E. M. Irwin is Chief Engineer, Magnetest Corp., Long Beach, Calif., and that he had been Manager, Pacific Coast Branch, Waugh Laboratories, Los Angeles Calif. This should be just the reverse—Mr. Irwin is now connected with the Waugh Laboratories. During preparation of Bulletin copy this information was transposed.

E. V. Romaine, formerly Director of Technical Sales, Newport Industries, Inc., New York, N. Y., is now Manager of Technical Sales, E. W. Colledge, General Sales Agent, Inc., New York, N. Y.

L. F. Rader is on leave of absence from the University of Wisconsin, Madison, Wis., and is Lieutenant-Commander, CEC-V(S), U.S.N.R., Public Works Officer, U. S. Naval Station, New Orleans (Algiers), La.

J. T. Spears is now Line Foreman, Canadian Car Munitions, Ltd., Montreal, P. Q., Canada. He was connected with the Sorel Steel Foundries, Ltd., Sorel, P. Q., Canada, as Metallurgist.

L. C. Conradi, member of the Society for many years, who for about ten years was in charge of the technical and research activities of the International Business Machines Corp., during which time an extensive and well-equipped laboratory was established, has become affiliated with the Standard Steel Spring Co., as Ordnance Chief Metallurgist. A complete chemical and physical laboratory is being installed to facilitate the heat treatment of armor plate, bombs, and shot.

A. E. Stacey, Jr., formerly Vice-President and Chief Engineer, Buensod-Stacey Air Conditioning, Inc., New York, N. Y., is now on active duty with the Navy at Pearl Harbor.

Ruth L. Payne, who was Chief Chemist, American Electro Metal Corp., Yonkers, N. Y., is now Chemist (organizing a control and research laboratory) for Connecticut Telephone & Electric Co., Meriden, Conn.

H. S. Schenker, Textile Consultant and Director, Consumers, Testing Laboratories, Philadelphia, Pa., has been appointed Head of the Textile Unit in the Standards Section of the Consumer Division, Office of Price Administration.

H. R. Lee, formerly In Charge of Laboratory, Cia. Cubana de Electricidad, Havana, Cuba, has returned to this country from Havana, after a ten years' absence, and is serving as Water Supervisor for E. I. du Pont de Nemours and Co., at an ordnance plant.

The following A.S.T.M. members were recently awarded medals by the Franklin Institute: D. A. Abrams, Consulting Engineer, New York, N. Y.—Frank P. Brown Medal, given in recognition of his discovery of the fundamental bases of design for concrete and reinforced concrete mixtures; H. C. Drake, Director of Research, Sperry Products, Inc., Hoboken, N. J.—Howard N. Potts Medal, in consideration of inventions and important work in the development of the rail fissure detector car, affording valuable results in the saving of life and property; and P. D. Merica, Vice-President and Director, The International Nickel Co., Inc., New York, N. Y.—Franklin Medal and Certificate of Honorary Membership, in recognition of his theoretical work on the precipitation hardening of alloys, and of his practical work in the development of the art of heat treatment of such alloys to the end that they acquire properties which make them commercially of greater usefulness.

Walter M. Scott, Chief, Cotton Chemical Finishing Division, U. S. Bureau of Agricultural Chemistry and Engineering, Southern Regional Research Laboratory, New Orleans, La., has entered the Service and is now Lieutenant-Colonel, Research Division of Technical Service, Office Chief Chemical Warfare Service, Washington, D. C.

J. Strother Miller, Technical Adviser of the Barber Asphalt Corp., Perth Amboy (Barber Station), N. J., has retired after 33 years of service in all phases of the technical activities of that company. Mr. Miller will continue his interest in asphalt technology as a consultant. He resides at 1084 Bryant St., Rahway, N. J. Mr. Miller is active in A.S.T.M. committee work, serving on Committees D-4 on Road and Paving Materials, D-8 on Bituminous Waterproofing and Roofing Materials, and on Technical Committee XII on Laboratory Apparatus of Committee E-1 on Methods of Testing. During his many years of activity with A.S.T.M. (membership dating from 1903) he has contributed a great deal to A.S.T.M. technical work and has prepared a number of technical papers and reports published in the Society *Proceedings*.

F. C. Elder, formerly Chief Metallurgist and Director of Research, American Steel and Wire Co., Cleveland, Ohio, has been named Research Engineer—Special Assignments for the Vice-President. Succeeding Mr. Elder as Director of Research is J. S. Richards, formerly an A.S.T.M. member. He is being succeeded as Manager of the Metallurgical Department by J. R. Thompson, who has been Assistant Manager, Metallurgical Department, and L. H. Dunham, formerly Works Metallurgist at Waukegan, Ill., has been transferred to Cleveland as Assistant Manager, Metallurgical Department, succeeding Mr. Thompson.

At the recent annual meeting of the American Foundrymen's Association, D. P. Forbes, President, Gunite Foundries Corp., Rockford, Ill., was elected President. A. L. Boegehold, Chief Metallurgist, General Motors Corp., Research Laboratories, Detroit, Mich., received the J. H. Whiting Gold Medal.

F. Malcolm Farmer, a past-president of the Society and very active in A.S.T.M. work, in addition to continuing his responsibilities as Vice-President and Chief Engineer of the newly organized Electrical Testing Laboratories, Inc., is devoting a major portion of his time as Coordinator of Inspection, New York Ordnance District Office, New York, N. Y.

Max E. Campbell, formerly Chief Chemist, Pioneer-Flintkote Co., Los Angeles, Calif., is now Quality Superintendent and Chief Chemist, United States Gypsum Co., South Gate, Calif.

N. F. Harriman is now Technical Assistant to the Director of the Procurement Division, Treasury Department, Washington, D. C. Mr. Harriman will continue to serve as Vice-Chairman of the Federal Specifications Executive Committee and will have general supervision over all the detail work of its technical committees. He will also approve for the Director, all Federal and Procurement Division specifications and deviations from Federal Specifications.

C. S. Neal, who has been in the Furniture Technical Service of The Sherwin-Williams Co., Chicago, Ill., is now Production Manager, Illinois Ordinance, Sherwin-Williams Defense Corp., Carbondale, Ill.

L. W. Parsons, formerly Chief Technologist of the Tide Water Associated Oil Co., New York, N. Y., is now Manager, of the Washington Office of this company.

45th A.S.T.M. Annual Meeting

June 22 to 26, Chalfonte-Haddon Hall, Atlantic City

For Provisional Program, see p. 55

ARTHUR NEWELL TALBOT
(1857–1942)

In the death on April 3, 1942, of Arthur Newell Talbot, the Society loses one of its most eminent members, a former President, 1913–1914, and Honorary Member, 1923, one who contributed in innumerable ways to the advancement of the Society's work in the standardization of specifications and tests for materials, and notably in its activities involving research. To the councils of the Society he brought an unexcelled knowledge of materials, a profound appreciation of the importance of A.S.T.M. work, and an intuitive grasp of administrative matters which, coupled with his knowledge of men, resulted in many constructive suggestions in forwarding various phases of the Society's activities. When he was awarded in 1937 the famed John Fritz Medal for notable scientific and industrial achievement, he was cited as "a moulder of men, eminent consultant on engineering projects, leader of research and outstanding educator in civil engineering."

Doctor Talbot's wide range of activities in so many fields is in part evidenced by the honorary memberships conferred, which in addition to the A.S.T.M. in 1923, included the American Society of Civil Engineers, 1925; American Waterworks Association, 1930; American Concrete Institute, 1932; and American Railway Engineering Association, 1933. To all of these fields he contributed greatly. He had been a past-president of the A.S.C.E. and the Society for the Promotion of Engineering Education and served several terms as a Director of the A.R.E.A.

Born October 21, 1857, in Cortland, Ill., a small village west of Chicago, his early education was obtained there and in a neighboring high school, and at the age of 20 he entered the University of Illinois and was graduated in 1881. For four years he was engaged in railroad location and construction in the west, and in September, 1885, he was appointed Assistant Professor of Engineering and Mathematics at the University of Illinois which title five years later was changed to Professor of Municipal and Sanitary Engineering, in charge of Theoretical and Applied Mechanics. He did early pioneering work in numerous fields including development of formulas for areas of waterways for bridges and culverts, and for rates of maximum rainfall, and also for developing methods for laying out easement curves at the ends of circular curves in the railroad field. His activities in sewage treatment were notable and also in carrying out investigations for testing paving brick for strength and abrasion. Perhaps his most notable work was done in the field of concrete and reinforced concrete and in the investigation of railroad track, termed "Stresses in Railroad Track" which led to authoritative information on properties, actions, and resistance in various parts of the track structure, under the application of various loads.

A member of the A.S.T.M. since 1898, he served on numerous technical committees and contributed a number of papers, reports, and discussions to the A.S.T.M. publications. In fact, his interest in this phase of the work was evidenced by service for ten years on the Committee on Papers and Publications dating from its organization in 1913.

It was fitting that he should be selected as the first Edgar Marburg Lecturer, which he delivered in 1926 on the subject, "Research and Reinforced Concrete as an Engineering Material." His interest in the research phase of A.S.T.M. work is evident in a quotation from his 1914 presidential address, "Research and the Activities of the Society."

> "Ultimate progress involves a searching, critical, and thorough inquiry and investigation into the facts and principles relating to the subject. Real research lies at the basis of that complete and definite knowledge of the properties and actions of engineering materials that is so essential in the formulation of specifications for the selection of materials, and in the understanding of the nature of the resistance of the machines and engineering structures in which they are used; and more and more as time goes on will the Society need to avail itself of the fruits of research."

In 1936 he prepared a short message on conditions in the early Society years and in which he asked for continued service. Excerpts from this are significant in appreciating his interest in A.S.T.M. and its work:

> . . . The new Society had many obstacles to overcome. It was without precedents. It learned to do by doing. It developed methods, procedure, standards. It encouraged research and recognized its value wherever found. It fostered cooperation. It coordinated the efforts of the many. Soon it had expanded its field and trebled and quadrupled the number of its working committees. Before long it had established a reputation for fairness of procedure, correctness of information, soundness of judgment, fullness of research data, and the stability of its organization. . . .
>
> . . . The American Society for Testing Materials has made a creditable record. In dependable research, in the building of specifications and the making of standards, in developing testing methods and in standardizing procedure, in dissemination of knowledge and in cooperational activities, the Society has reacted as one having a mission. For these maturer years the Society will be engulfed among new problems in a widened field. Since 'new occasions teach new duties,' the newer generation will have new opportunities and new responsibilities. Fortunately under the past leadership of the Society, many young men are growing up and developing in the *science and art of testing materials* and should be willing and able to bear the burden of a new generation. . . .

His death removes from the ranks of the Society one whose engineering and technical judgment was held in the highest regard, whose contributions to the field of testing materials were widely acclaimed and appreciated, and whose qualities as an associate and friend endeared him to all. In extending their sincere sympathies to his family, the officers and members of the Society also record their appreciation for his inspiring life and his work in A.S.T.M.

GUSTAVE WHYTE THOMPSON
(1865–1942)

It is with keen regret that we announce the death on April 22 of Dr. G. W. Thompson, Past-President and Honorary Member of the Society. Doctor Thompson was Chief Chemist of the National Lead Co. from the time of its organization in 1892 until his retirement four years ago. Many of its technical processes had been developed under his direction. Its research laboratory was organized entirely under his guidance and he built it up with the plan of undertaking investigations of problems as they arose in connection with practical needs. He was considered an international authority on lead and its uses and has probably done more than any other individual

to develop the scientific aspects of the lead industry. The technical literature is replete with his contributions, many of them relating to non-ferrous metals, pigments, particle size, color, and linseed oil. During the first World War, it was under his direction that a smelting plant was established in this country for producing tin from South American ore.

He was frequently looked to for executive direction in Society affairs. He was a member of Committee D-1 on Paint, Varnish, Lacquer, and Related Products from the time of his joining the Society in 1903, and was secretary of the committee from 1910 to 1920 during which period an extensive series of test programs was being carried out. He was called upon as one of the original advisory members in the organization of Committee E-8 on Nomenclature and Definitions on which he served from 1922 to 1939. He served in a similar capacity on Committee E-1 on Methods of Testing when this committee was organized and served on the Advisory Committee from 1920 to 1926. He twice served as a member of the Executive Committee from 1912 to 1913 and from 1916 to 1918; in 1926 he was elected Vice-President, and became President of the Society in 1928. He was elected Honorary Member of the Society in 1937. In 1938 he was elected a member of the Board of Directors of the American Standards Assn.

Doctor Thompson was noted for his excellent judgment, his keen analysis of problems, and particularly for his facility for the exact and precise statement of his views. But above all he was revered for his kindly approach and his tact in dealing with his colleagues and associates. He always took a keen interest in the welfare of the organizations with which he was associated as may very well be appreciated from the following quotation from his Presidential Address, presented before the Society in 1929 which gives an insight into his character:

> "Our Society occupies an impregnable position, impregnable so long as we perform our functions rationally, justly, and with a continuous process of development. Our object is to build as far as we can on sound foundations, going only as far and as fast as we feel that the circumstances justify. We aim to move constantly forward, requiring no push or prod, for our aims are clear and our methods of procedure have stood the test of time. . . . I trust that our future will far exceed in brilliance our past in the service which we are rendering to industry, to our country, and to the world at large."

The officers of the Society and all who were associated with him mourn his passing and extend their heartfelt sympathies to his family. They will cherish in their memories the years of association with him, and his life will ever be an inspiration.

George L. Norris
(1866–1942)

An outstanding metallurgical engineer who for many years had taken a leading part in the development of vanadium steels, G. L. Norris, had been continuously a member of the Society since 1902 and active in many of its projects. He had been a member of Committee A-1 on Steel for almost 30 years where his primary interest concerned subcommittee work dealing with springs, forgings and castings. His membership on Committee B-2 on Non-Ferrous Metals and Alloys dated from 1910. A graduate of Massachusetts Institute of Technology he had experience with various companies including the Pennsylvania Steel Co., Pencoyd Iron Works, Great Northern Railroad and Standard Steel Works, where he was Engineer of Tests. His service with Vanadium Corporation of America, of which he was Chief Metallurgical Engineer, was continuous except during the first World War when he was Chief Metallurgist, Bureau of Aircraft Production. He was interested and active in the work of a number of other organizations. In his death the Society loses a long-time member who contributed much to the advancement of its work.

W. E. Carson
(1870–1942)

W. E. Carson, long-time member of the Society and prominent industrialist, public servant, and for many years President of the National Lime Manufacturers Association, died on March 25, 1942, after a long illness. Identified throughout his lifetime with the Riverton Lime and Stone Co., of which he had been President since 1904, Mr. Carson won unusual distinction in his field of industry. He had been a member of the Society since 1912, and served on Committees C-1 on Cement and C-7 on Lime. At the time of his death he was chairman of the subcommittee on hydraulic lime and was vice-chairman of Committee C-7.

During the first World War he did notable work in insuring maximum cooperation from the lime industry for which he was cited and he received many other honors. He rendered distinctive service to the state of Virginia and was the father of the conservation movement in that State. He was the first chairman of the Virginia Conservation and Development Commission and he guided notable developments in his state including the Skyline Drive, Colonial National Monument linking Williamsburg, Jamestown, and Yorktown, and other state park systems.

William E. Woodard
(1873–1942)

Mr. Woodard was another of the group of five long time A.S.T.M. members who have recently died. A leading technical authority in the locomotive manufacturing field, he had for many years been Vice-President and Director of the Lima Locomotive Works; his chief responsibilities involved designing. Since 1916 he represented his company's membership in the Society, and for almost 25 years, he had served on Committee A-1 on Steel and several of its subcommittees—those concerning steel castings, tubing and pipe, and boiler steel.

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